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The PROGRESSIVE FISH-CULTURIST

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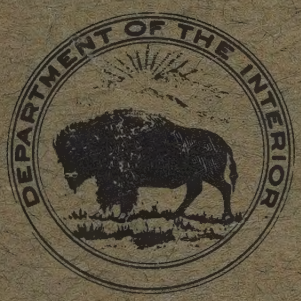

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PROGRESSIVE FISH-CULTURIST

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(See inside back cover)

The PROGRESSIVE FISH-CULTURIST

News and Views from many Sources on Practical Hatchery Problems

Volume 10 | Washington, D. C. | October 1948 | Number 4

TABLE OF CONTENTS

	Page
Cement: Its Preparation and Use in Fish-Management Projects, by the Portland Cement Association	163
Management of Game Fish of Conchas Reservoir, by C. M. Mottley and T. K. Chamberlain	177
Bangos Culture in the Philippines, by W. F. Carbine	187
Increasing Production of Bluegill Sunfish for Farm Pond Stocking, by E. W. Surber	199
New Substances of Possible Value in Fish Disease Control, by Max Katz	204
New System of Trout Distribution in West Virginia, by E. A. Seaman	206
Improved Rearing Pond, by Marshall Thayer	209
From Publications	
Reprint:	
Two Years of Fishing in Lakes with Liberalized Regulations, by H. E. Predmore, Jr.	215
Wormy or Grubby Fish, by G. W. Buller	218
Abstract:	
Propagation of Minnows and Other Bait Species, by J. R. Dobie, O. L. Meehean, and G. N. Washburn	219
Clearing House	219
Items	
Other	176
Washington Monument Lot: Fishponds	198
Designing Farm Ponds	212
Comments	213
Index	221

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CEMENT: ITS PREPARATION AND USE IN FISH-MANAGEMENT PROJECTS

PONDS, FISH LADDERS, AND HATCHERY BUILDINGS

Portland Cement Association
33 West Grand Avenue
Chicago 10, Illinois

FISH, unlike the fabled Topsy of "Uncle Tom's Cabin," do not just grow. Countless thousands of our piscatorial friends in American waters owe their very existence to the pampering and scientific care they receive in fish hatcheries throughout the United States. Almost universally in these hatcheries--and in the construction of fish ladders, too--the use of concrete is playing an ever more important part in cementing the three-cornered relationship between fish-culturists, fishermen (commercial and otherwise), and the fish themselves.

Durable concrete makes clean, healthful pools for the hatcheries and fishways, provides protection against weather and decay, and reduces to a minimum the costly burden of repairs and maintenance. Knowledge of the use and proper application of concrete is an important tool in the hands of the people to whom the preservation and the propagation of fish in this country have been entrusted.

Concrete is widely used in three different types of construction to assist in fish management and to help produce and maintain "good fishing." First of all, concrete is generally accepted for construction of spawning and rearing ponds in hatcheries. Second, some hatcheries, a notable example being the U. S. Fish-Cultural Station near Leavenworth, Washington, have gone all out for concrete, constructing of concrete the administration buildings as well as the fish ponds. And last, many of the nation's finest fish ladders--which permit fish a safe journey over man-made obstacles--are constructed of concrete.

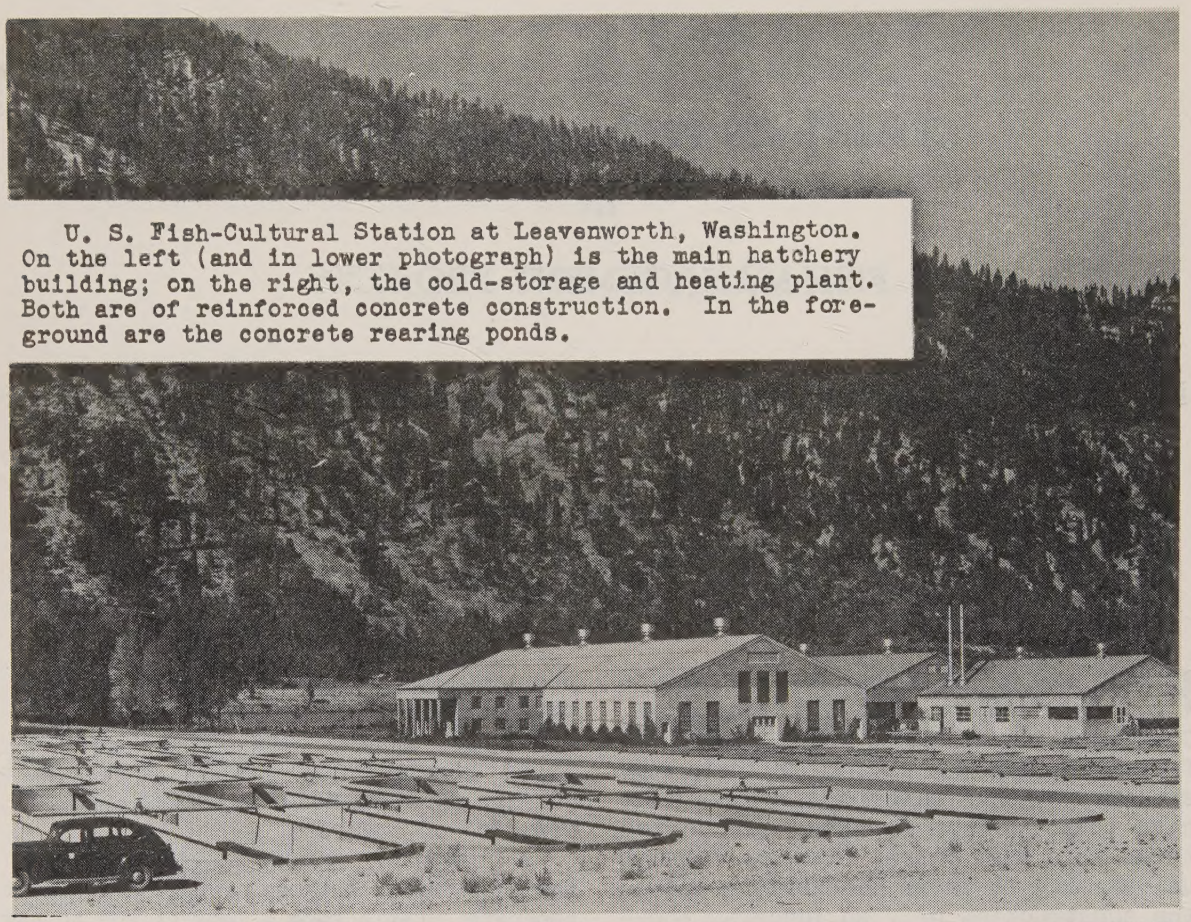
A number of general rules apply in the preparation and use of portland cement concrete. Let's take a look at the things which make up good-quality concrete and apply some of them to hatchery construction. Then we'll tackle a few specific problems in the use of concrete in hatchery ponds, hatchery buildings, and fish ladders.

The making of good concrete involves: (1) selecting the proper ingredients; (2) proportioning them correctly; (3) mixing them properly; (4) making, shaping, and bracing the forms; (5) placing the concrete in forms; (6) finishing; and (7) curing.

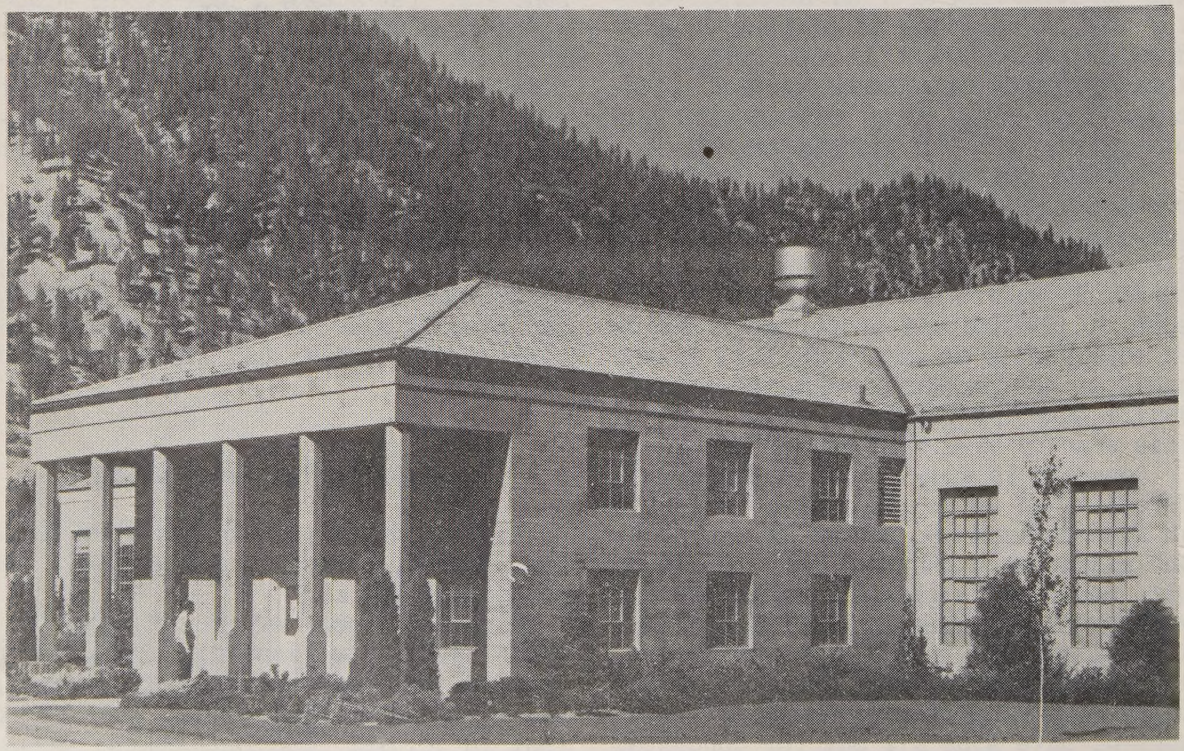
SELECTING THE INGREDIENTS

The ingredients of concrete are portland cement, water, fine aggregate, and coarse aggregate.

Portland cement may be obtained from building-material dealers. It comes in cloth or paper sacks, each sack containing 94 pounds of cement, equal to 1 cubic foot in volume. Portland cement should



U. S. Fish-Cultural Station at Leavenworth, Washington. On the left (and in lower photograph) is the main hatchery building; on the right, the cold-storage and heating plant. Both are of reinforced concrete construction. In the foreground are the concrete rearing ponds.

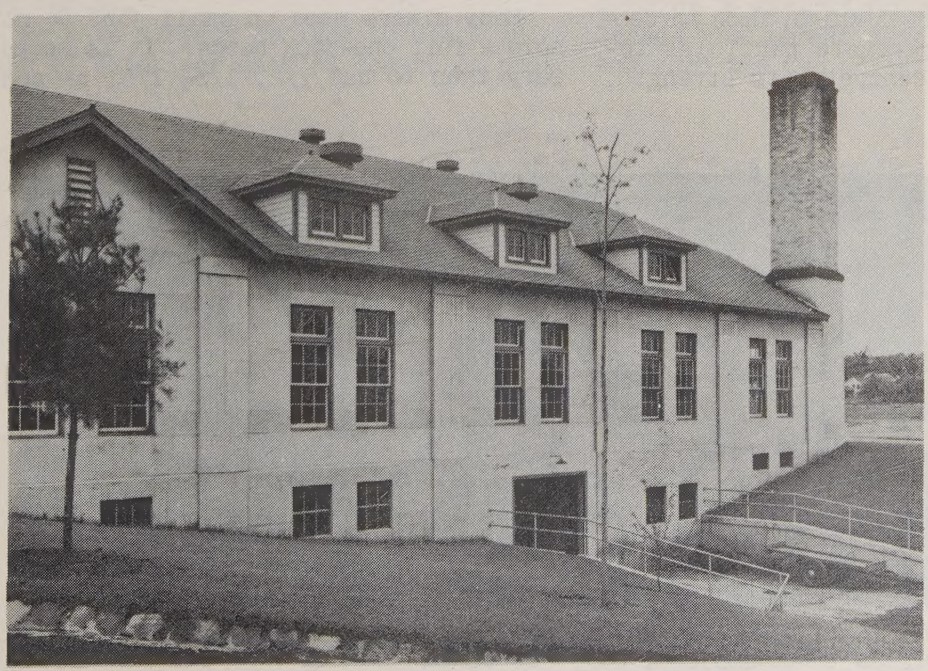


(Photographs on this page courtesy of the Bureau of Reclamation)

These and following photographs courtesy of Portland Cement Association.

Mechanical repair and storage building of the Southern Area State Fish Hatchery, near Madison, Wisconsin. Reinforced architectural concrete.

Office and mechanical repair building of the Northwest Fisheries Area Headquarters in Spooner, Wisconsin. Reinforced architectural concrete.



be free-flowing powder when used. If it contains lumps that cannot be pulverized between thumb and finger, it should not be used. Portland cement should be stored in a dry place.

In general, water that is fit to drink is suitable for making concrete. Water should be clean and free from oil, acid, or alkali.

Fine aggregate consists of sand or other suitable fine material. A good concrete sand will contain particles graded uniformly in size from very fine to those which will just pass through a 1/4-inch screen.

Coarse aggregate consists of gravel, crushed stone, or other suitable materials larger than 1/4 inch. Coarse aggregates that are sound, hard, and durable are best suited for making concrete. Those that are soft or flaky or wear away rapidly are generally unsatisfactory. Good aggregates are clean and free from loam, clay, or vegetable matter. Coarse aggregate is well graded when the size of the particles ranges from a quarter of an inch to not more than a fifth of the thickness of the concrete being placed.

DETERMINING THE PROPORTIONS

Cement paste (cement and water) is the cementing material which, upon hardening, binds the aggregate particles together and gives concrete its strength, durability, and watertightness. These properties are determined largely by the amount of water used per sack of cement. In general, the less water used, the better the quality of the concrete, so long as the mixture is plastic and workable. Thus, for example, in the construction of strong, watertight hatchery ponds, the amount of water used must be limited.

For such ponds and similar watertight construction, it is recommended that the concrete contain not more than 6 gallons of water--including that carried by the aggregate--to each sack of portland cement. The amount of water to add when fine aggregate is damp, wet, or very wet, is shown in table 1.

Most fine aggregate contains some water. In determining the amount of water to add to the mix, allowance must be made for this moisture as indicated in table 1. Otherwise, the mixes will contain more than the correct amount of water to get the quality of concrete desired. A simple test for determining whether sand is damp, wet, or very wet, is to press some together in your hand. If the sand falls apart when your hand is opened, it is damp; if it forms a ball which holds its shape, it is wet; if the sand sparkles and wets your hand, it is very wet. If the sand is bone dry, the full 6 gallons of water may be used.

Many mixers used on small jobs do not hold a full one-sack batch. It is necessary then to use 1/2, 1/3, 1/5, or some

If it falls apart, the sand is damp.

If it forms a ball, the sand is wet.

If it sparkles and wets the hand, the sand is very wet.

other fraction of a sack of cement per batch. The amount of water to be measured for each batch will depend upon the amount of cement used. An easy method of measuring water is to use the volumetric proportions listed in table 2.

For a 6-gallon mix made with wet sand, use two-thirds as much water as cement. Suppose, for example, the mixer can mix only a half-sack batch. Divide a sack of cement equally into two large paint pails or similar straight-sided containers. Shake down thoroughly and mark the height of the cement. Empty the container and measure the height of the mark from the bottom. Make another mark, two-thirds as high as the first, inside the container. When measuring water, fill to the lower mark.

In making a 6-gallon mix with damp sand, the volume of water is increased to three-fourths of the volume of cement.

PREPARING A WORKABLE MIXTURE

A workable mix is one that is smooth and plastic and that will place and finish well. It should not be so thin that it runs or so stiff that it crumbles. It should be rather sticky when worked with a shovel or trowel. For most uses a workable mix is one which is "mushy" but not "soupy."

We have already decided to use 6 gallons of water per sack of cement to produce a concrete that will withstand the elements and the service to which fish-hatchery construction will be subjected. The next step is to proportion the fine and coarse aggregates in such a way that the finer particles will just fill the voids between the larger ones. The average proportions of cement, sand, and coarse aggregate graded to 1-inch maximum size for workable mixtures are:

1 part cement 2¼ parts sand 3 parts coarse aggregate	6-gallon mixture

If the proportions suggested do not make a workable mixture in the first trial batch, change the proportions of sand and gravel slightly for the next batch but do not change the amount of water.

A machine mixer of the drum type is best. It should be run at a speed slow enough to allow the materials time to fall away from the top of the drum as it revolves. Avoid overloading the mixer, as this prevents the proper mixing action. Continue mixing until the cement paste completely covers all particles of aggregate and fills the voids between them.

Concrete can be mixed by hand if the mixing is thoroughly done. Hand-mix as follows: Place the measured amount of sand on a watertight mixing platform. Spread the cement evenly over the sand and turn the two materials with a shovel

TABLE 1.--Mixture of water and fine aggregate

Mix	Use when sand is:		
	Damp	Wet	Very wet
6 gallons per sack of cement	5-1/2 gallons	5 gallons	4-1/4 gallons

TABLE 2.--Volumetric proportions of water and cement

For	Use when sand is:		
	Damp	Wet	Very wet
6-gallon mix	3/4 volume water to 1 volume of cement	2/3 volume water to 1 volume of cement	9/16 volume water to 1 volume of cement

Making a trial batch with separated aggregates and a 6-gallon mix.

1. Tested for moisture, this sand has been found to be wet; therefore, only 5 gallons of water (see table 1) will be used per sack of cement. As the mixer holds only about a 1/5-sack batch, the proper amount of mixing water is 1/5 of 5 gallons, or 1 gallon.
2. Measure 4 quarts (1 gallon) of water into a pail or other container and place a mark at the water line. Thereafter fill to this mark.
3. When sand is wet, 1-1/2 volume of cement should be used to each volume of water (see table 2). As this batch is to receive 4 quarts of water, 4 x 1-1/2 or 6 quarts of cement will be required. Measure 6 quarts of cement into a pail, level it off, and mark the pail at the top edge of the cement. Thereafter fill pail to this mark.
4. Put measured amount of water (4 quarts) into mixer. (1/5 sack of cement in batch.)
5. Add part of gravel (coarse aggregate). Adding gravel to the water before cement is added will prevent cement paste from sticking to mixer drum.
6. Add measured amount of cement (6 quarts).
7. Add sand and gravel in proper proportions until a mushy, workable mix is obtained. In mixing a trial batch, first try the proportions given on page 167.
8. Usually 1 to 2 minutes are required for mixing after all materials have been added. Always run mixer at speed recommended by the manufacturer.
9. When all particles are coated with cement paste, dump out the concrete.

until a uniform color shows that the sand and cement are thoroughly mixed. Spread this mixture out evenly and add the measured amount of gravel. Mix thoroughly again. Form a hollow in the material and slowly add the measured quantity of water. Continue mixing until every particle has been completely covered with cement paste.

MAKING AND SHAPING THE FORMS

Forms are the molds or receptacles into which the concrete mixture is placed so that it will have the desired shape when hardened. Concrete, being plastic at the time of mixing, can be made into almost any desired shape. Forms must be substantial enough to retain their correct shape when filled, as freshly mixed concrete exerts great pressure. It is not sufficient that forms be strong; they must also be rigid and tight enough to prevent leakage of mortar. Disappointment will result if one finds after concrete is placed that the forms are bulged by resulting pressures. If the forms are not tight, the escape of the water-cement paste from small openings will change the character of the remaining mixture. Forms should be designed to facilitate their removal after the concrete has hardened. Double-headed nails or screws which can be withdrawn readily will greatly assist in removing forms without damaging the new concrete.

Lumber is the most satisfactory material for normal use in constructing forms for hatchery ponds. The lumber should be sound, free from knotholes and decay, and dressed on at least one side and both edges. Forms may be built in sections or panels so constructed that they can be removed easily and used in other work.

To prevent concrete from sticking to the forms and to make form removal easy, it is customary to oil form faces which come in contact with concrete. A light, clear lubricating oil is suitable for this purpose. For easy brushing, the oil should be cut with about an equal amount of kerosene. Forms should be cleaned and oiled each time they are used. Dry, untreated wood forms will absorb water from the concrete, often leaving the surface too dry for best results. Forms may warp badly unless oiled.

After forms are made, they should be well braced in position to prevent bulging while the wet concrete is being tamped into place. Wood spacers should be used for walls to hold opposite form faces the correct distance apart. Wire ties, passed through or around form studs and across the space between forms, tighten the forms against the spacers and hold them true so that the finished wall will be straight and uniform in thickness. For most exposed work, however, form ties that are completely removed after the concrete has hardened or that leave no metal within 1-1/2 inches of the surface, give better results. The holes left by the ties are plugged with cement mortar.

USE OF THE FORMS

The concrete mixture should be placed in the forms soon after mixing. The concrete must be plastic when placed, so that it will fill the forms without honeycomb or air pockets.

On small jobs wheelbarrows are the usual means of transportation. On larger jobs buggies or buckets are commonly used. Whatever method is used, care should be taken to prevent separation of the coarse aggregate from the mortar or of the water from the concrete. Such separation is likely to occur when wet concrete is transported over rough ground or runways. Avoid "sloppy" mixtures because they segregate badly.

Deposit the concrete in level layers not more than 12 inches deep at one time, tamping and spading just enough to make it settle thoroughly and produce a dense mass. Working the concrete next to the forms insures an even, dense surface when forms are removed.

It is just as important to prevent segregation in the forms as when transporting the concrete from the mixer to the forms. Depositing the concrete uniformly around the forms where it is to be used, rather than placing it at a few points and dragging it or causing it to flow where needed, helps prevent segregation and honeycombing.

Further care is required to see that the material is properly worked into the corners and angles of forms and, in re-

Forms should be made so the concrete can be spaded easily, especially next to the forms.

Surfaces that will be next to the concrete should be oiled thoroughly. Oil prevents (1) the wood from absorbing water from the concrete; (2) the forms from warping; and (3) the concrete from sticking to the forms.

inforced work, around reinforcement.

If the mixture becomes sloppy as the forms are filled, use a stiffer mixture. Change consistency by varying the amount of aggregate, not the water.

At the end of the day's run or when the work has to stop long enough for the concrete to begin hardening, roughen the top surface just before it hardens: this is to provide a good bond for the next layer of concrete. Just before resuming the placing of concrete, clean the roughened surface and then brush with a cement-water paste of a thick, creamy consistency. This paste is applied in a thick brush coat just ahead of the concreting operation, so that the paste does not have a chance to dry before it is covered with concrete. This precaution to get a good bond between different layers of concrete is very important wherever the concrete construction is to be watertight. Insofar as possible, construction joints should be avoided in tanks and similar work.

Where construction requires the installation of conduits, pipes, and other service leads, these should be put in place before concrete is placed.

Ordinarily forms should be left in place for at least 7 days in summer and 14 days in cold weather. Forms must never be removed until it is certain that the concrete has hardened enough to be self-sustaining.

FINISHING AND CURING

The final finishing of unformed surfaces is delayed until the concrete has hardened enough to become quite stiff;

(Opposite page)

Wooden forms, when built in sections, are easily erected and removed and may be used many times. Sections should not be too long or too heavy for two men to lift. The forms shown here would be more convenient if they were made in sections half as long.

Forms for concrete construction must be well braced to withstand pressure of the wet concrete. Stock lengths of lumber are used without cutting whenever possible.

then finishing is done with a wood float which results in a uniform gritty surface. Where very smooth surfaces are desired, the floating is followed by troweling with steel trowels.

Proper curing of concrete improves its strength, durability, and watertightness.

Concrete hardens because of chemical reaction between the portland cement and water. Hardening continues as long as temperatures are favorable and moisture is present to hydrate the cement.

Moist curing greatly increases the strength of concrete. Tests show that concrete damp-cured for 7 days will be approximately 50 percent stronger than similar concrete which is permitted to dry out.

Concrete cured at 70° F. generally hardens more than twice as fast as concrete cured at a temperature slightly above freezing.

Thorough moist-curing aids in producing watertight concrete. As the cement paste in concrete hardens, additional solid matter is formed, closing off the space between the cement particles through which water might otherwise seep. The more complete the hydration or the hardening process, the denser and more watertight becomes the cement paste.

Cover with wet burlap, canvas, sand, or straw coverings as soon as it can be done without marring the surface. Keep the covering continuously wet by sprinkling.

Spawning ponds and other hatchery construction require careful attention, as moisture is lost very rapidly by evaporation on large exposed surfaces.

Vertical surfaces can be protected by leaving the forms in place temporarily or by hanging canvas or burlap over them. Such coverings are kept constantly moist by sprinkling. Curing should continue for at least 5 days and for longer periods of time when it is practical to do so.

CONSTRUCTING THE HATCHERY PONDS

The above material should give you a good background for the preparation and use of concrete in hatchery construction. Now let's examine a few of the specific problems which may be peculiar to this type of work.

Both spawning and rearing ponds must be built to withstand water pressure from within and soil pressure from without. They must be clean and healthful and therefore watertight. Selecting the proper mix is vitally important in obtaining a satisfactory finished product.

Under certain conditions, such as in strongly alkaline soil, it may be desirable to provide a richer mix which will give a denser concrete. In these locations, a mix containing 5 gallons of water per sack of cement is suggested. The usual proportions of fine and coarse aggregates for this mixture are:

1-3/4 parts sand) 5-gallon
2 parts gravel) mixture

It may be necessary to vary the proportions of the fine and coarse aggregates slightly to obtain a smooth, plastic, workable mix, but the amount of water should not be varied. If the trial proportions result in a mix that is too wet, small amounts of fine and coarse aggregates should be added until the right degree of plasticity is obtained. If the mix is too stiff, the amounts of fine and coarse aggregates in the next batch should be cut down until the right consistency is obtained. In this way the best proportions for the job can be determined.

CONCRETE AND THE WEATHER

Weather may also be an important factor in your concrete hatchery construction. Naturally, mild or warm weather is preferable for this type of work. Heat hastens the hardening of concrete; cold retards it. When temperatures fall below 50° F., the retarding effect of cold becomes particularly noticeable; as temperatures approach freezing, the effect is very marked. Concrete should harden at least 48 hours under favorable conditions, and it is better to protect new concrete from freezing for 4 or 5 days.

If work must be done during cold weather, sand, pebbles, and water should all be heated separately. This applies if

the temperature is below 40° F.

Frost, snow, and ice should always be removed from the forms before the concrete is placed. It is desirable that the concrete have a temperature of at least 70° F. when placed in the forms. This makes it necessary to deposit the concrete immediately after mixing. Forms must not be removed until concrete has been carefully examined to determine whether it has hardened sufficiently.

STRUCTURAL TYPES

The most common type of hatchery-pool design is one in which the floor of the pond is cast integrally with the wall. This design, which resembles an open top box, is particularly recommended for the small, shallow ponds.

An excellent example of this type of pond is provided by the hatchery of the U. S. Fish-Cultural Station at Coleman, near the Shasta Dam on the upper Sacramento River. This fish-management plant, with a capacity of 50 million eggs, has 28 reinforced concrete ponds to receive the young salmon after the incubation period.

Another common type of pool design--used for deeper pools--consists of cantilever wall with separate floor. This type is simple to design and construct.

The thickness of pond walls and floors is governed by strength requirements and by the minimum space needed for placing the concrete. In general, walls are not less than 4 inches thick. This thickness applies only to the shallow pools. Floors are usually from 4 to 6 inches thick.

Small or medium-sized pools may be built without construction or expansion joints, but the larger pools will require either or both. The proper location, design, and construction of these joints are very important in obtaining a watertight pool. Construction joints are intended to be rigid and to allow no movement, whereas expansion or contraction joints are intended to allow for the movement caused by changes in temperature and moisture content.

Construction joints should be avoided as much as possible by planning the work so that a complete section between expansion joints may be placed in one continuous operation. Special care is necessary to make joints watertight. Expansion joints should be filled with a plastic material which will allow the joint to move and will fill and seal the joint at all times. Expansion joints in walls usually have a water stop built in them in addition to the plastic material. The most common water stop is a crimped sheet of copper.

Expansion joints in floors should be made over a beam or footing or some special type of joint which will keep the adjacent slabs in line as well as be watertight. The proper location and spacing of expansion joints must be determined for each job. Ordinarily, the distance between joints should not exceed 60 feet.

SUBSURFACE DRAINAGE AND FOOTINGS

Too much cannot be said for beginning all concrete construction with adequate footings--placed on solid earth below the frost line in forms that are true to line and elevation. Usually the depth of the footing proper is equal to the thickness of the wall, while the width is twice as great.

The recommended mix for footings and foundations is 1 part of portland cement, 2-3/4 parts of sand, and 4 parts of gravel or crushed rock up to 1-1/2 inches in size. The proper amount of water to use with this mixture is 5-1/2 gallons for each sack of cement when sand is in average moist condition. Best results are obtained when a rather stiff, mushy mix is used. Concrete should be placed in forms in layers not deeper than 12 inches and should be spaded carefully along form faces as it is placed.

It is economically impractical to design the floor of your pools to resist the heaving action of frozen wet subsoil. Therefore, it is essential that the pools have adequate subsurface drainage. The minimum drainage system that should be considered is a line of tile around the outside of all footings. Strong, economical concrete tile with high resistant qualities is readily available for drainage installation.

Where the subsoil drains very slowly,

it will be advisable to place the floor on a bed (6 to 8 inches thick) of sand or cinders, thoroughly wetted, tamped, and rolled. If cinders are used, any metal pipe passing through them should be encased in concrete to prevent corrosion.

Most of these suggestions will generally apply to the construction of concrete pools for fish ladders. One additional problem may be encountered here: the possible necessity of doing the actual construction work under water. This has sometimes had to be done when fish ladders were not a part of the original construction of the dam or other man-made obstacle that prevents the migration of the fish.

Concrete should not be deposited under water unless it is impossible to place the concrete in air. There is always some uncertainty as to the results obtained from placing concrete under water. Where this must be done, a fairly rich mix containing at least seven sacks of cement per cubic yard of concrete should be used.

One of the most successful methods of placing concrete under water is with a steel pipe or tube called a tremie. The tremie must be long enough to reach the bottom of the work when the upper end is above water level. The lower end of the tremie is plugged to prevent the entrance of water or the escape of concrete. The tremie is filled with concrete and lowered into position. When the lower end reaches the bottom of the work, the plug is removed and the concrete allowed to flow out slowly. As work proceeds, the lower end of the tremie should be kept submerged in the concrete for several feet and the tremie kept constantly full of concrete.

For many years it was thought that the feasible limit on the height of fish ladders ranged between 60 and 75 feet. Experiments at the Baker River Dam in the State of Washington indicate, however, that fish ladders can be built over a dam of any height that it is practicable to build. In fish ladders scaling great heights, each step in the advance of the fish upstream is trapped so that the fish can't get back down.

ESTIMATING MATERIALS

Further information that may be of benefit to the hatchery cement-user is included in table 3, which shows how to estimate materials required for concrete of various thicknesses. The figures in each instance are based on the requirements for 100 square feet of concrete. Quantities may vary 10 percent either way, depending on the character of the aggregate used. No allowance is made for waste.

BUILDING WITH CONCRETE

The use of concrete in fish-management projects can happily extend far beyond the construction of spawning and rearing

TABLE 3.--Materials in concrete of various thicknesses

Thickness of concrete	Amount of concrete	Proportions								
		1:1-3/4:2 mix			1:2-1/4:3 mix			1:2-3/4:4 mix		
		Cement	Aggregate		Cement	Aggregate		Cement	Aggregate	
			Fine	Coarse		Fine	Coarse		Fine	Coarse
(in.)	(cu. yd.)	(sack)	(cu. ft.)		(sack)	(cu. ft.)		(sack)	(cu. ft.)	
3	0.92	7.5	12.9	14.7	5.8	12.9	17.5	4.6	12.9	18.4
4	1.24	10.0	17.3	19.9	7.8	17.3	23.6	6.2	17.3	24.8
5	1.56	12.5	21.9	25.0	9.8	21.7	29.6	7.8	21.8	31.2
6	1.85	15.0	25.8	29.4	11.5	26.0	35.2	9.3	26.0	37.0
8	2.46	20.0	34.6	39.8	15.4	34.4	46.8	12.3	34.4	49.3
10	3.08	25.0	43.8	50.0	19.3	43.2	58.5	15.4	43.2	61.6
12	3.70	30.0	51.6	58.8	23.1	51.8	70.4	18.5	51.8	74.0

ponds and fish ladders. Both concrete masonry and architectural concrete are ideally suited to the construction of hatchery buildings and are being used to advantage in a number of hatcheries.

The term "concrete masonry" is applied to block, brick, or tile building units molded from concrete. This familiar material serves a wide range of architectural and structural purposes, frequently combining the advantages of several materials and at a substantial saving.

As a structural material, concrete masonry is able to carry heavy loads. Because of its economy and high resistance to fire, it is widely used as back-up for all kinds of facing material, for fireproofing, and for floor filler.

Strictest requirements of building codes are met by concrete masonry, which, under careful tests, is found to possess many times the strength required in average construction. Units are scientifically designed and molded in sizes and shapes that permit speedy erection and consequent reduction in construction costs. Concrete masonry is adaptable to any style of architecture and is thus popular everywhere as a practical building material.

Several thousand manufacturers produce concrete masonry units of standard sizes and quality, serving practically every region of the United States and Canada. These units will provide strong, durable, fire-safe hatchery construction.

"Architectural concrete" refers to cast-in-place or reinforced-concrete construction in which the exposed concrete dictates the architectural appearance of the structure. This type of construction also is outstanding in fire-safety, economy of construction, strength, and minimum maintenance expense--and, in addition, lends itself easily and economically to an infinite number of designs. Almost any desired form, texture, or color can be obtained readily with architectural concrete construction.

As mentioned earlier, an excellent example of this type of building is at the U. S. Fish-Cultural Station near Leavenworth, Washington. Here the main hatchery building (225 feet long and 88 feet wide, with two wings each 36 by 45 feet in area), a garage, warehouse, and a cold-storage and heating plant, all are of attractive architectural concrete construction.

A number of similar hatchery building projects in concrete could be cited throughout the country. Two of these, of rather recent construction, may be found in the State of Wisconsin. The administration buildings of the Northwest Fisheries Area Headquarters at Spooner and the Southern Area State Fish Hatchery at Madison offer excellent examples of the use of architectural concrete in fish-hatchery construction. The hatchery buildings were designed by the Wisconsin Department of Architecture, and both projects were built in 1939 and 1940.

SUMMARY

These suggestions on the use and application of concrete are not intended to be all-inclusive, but they may give you a helpful background for planning concrete construction in your particular fish-management plant.

When building is on the docket at your hatchery, don't overlook the strength, durability, cleanliness, protection against weather and decay, and the low maintenance cost offered by the use of portland cement concrete. John Ruskin must have had concrete specifically in mind when he said, "This building shall not depend for its impressiveness upon anything that is perishable."

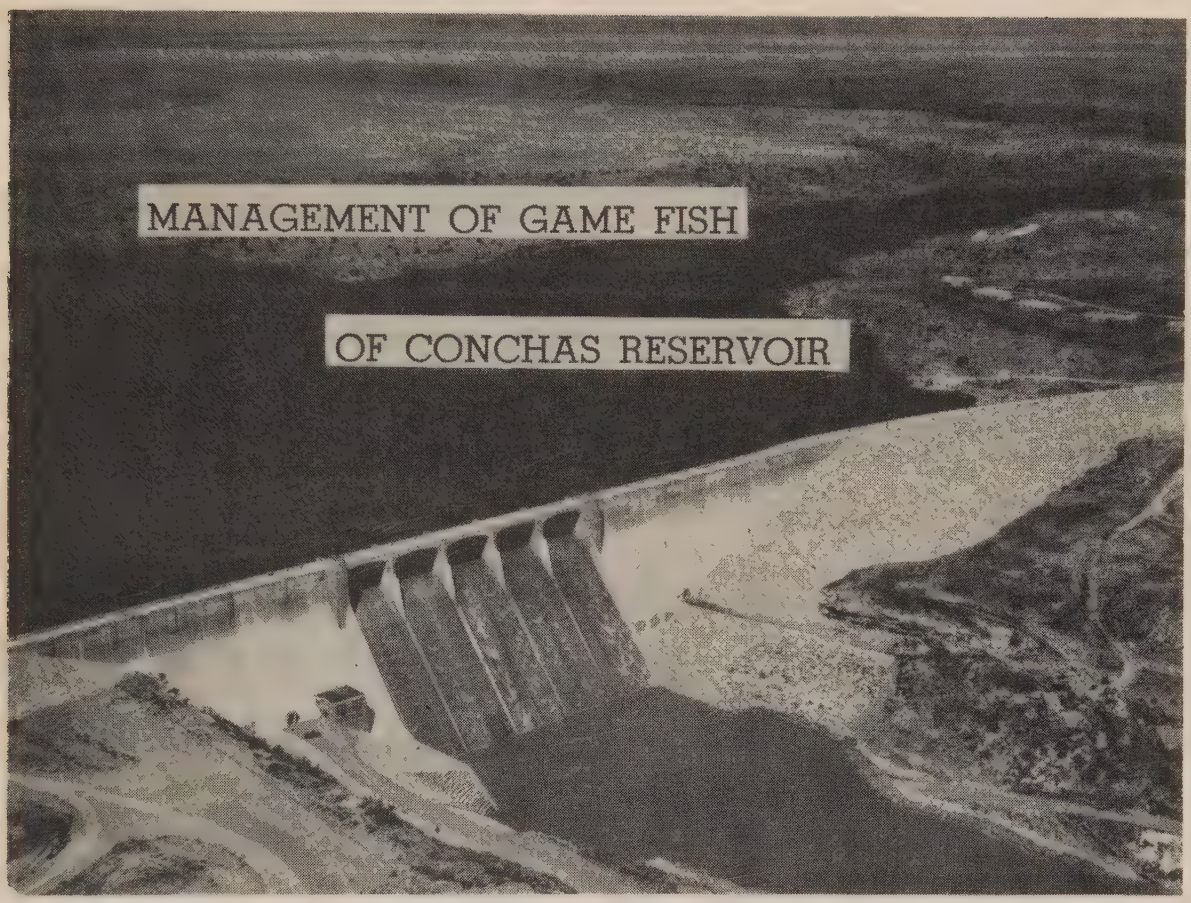
O T H E R

In accordance with Government regulation, the mailing list of the PROGRESSIVE FISH-CULTURIST has been prepared from cards signed and submitted twice a year by those who desire to continue to receive the publication. To determine the groups for which the PROGRESSIVE FISH-CULTURIST has the greatest value, eight classes of activity--Biologist-administrator, Fishery administrator, Fishery biologist, Fish-culturist, Hatchery superintendent, Sportsman, Student, and Other--have been listed on the cards, with the request that the principal line of activity be checked.

A survey of the cards received shows a considerable number of checks opposite "Other," and in many instances these checks have been expanded by a few words describing the signers' chief interests in which the PROGRESSIVE FISH-CULTURIST may be expected to be of assistance. More than 200 of these have described their principal activity as that of: schoolteacher, professor, game warden, game biologist, refuge manager, forest supervisor, park director, naturalist, sanitary biologist, wildlife engineer, flood-control engineer, soil conservationist, ecologist, parasitologist, aquarist, minnow dealer, live-bait dealer, fishing-pond operator, sports writer, outdoor editor, columnist, and commentator.

Perhaps the accolade was delivered by the man who added the statement: "I'll be glad to pay for a subscription."

Democritus assures us that if the tongue be extracted from a live frog, with no part of the body adhering to it, and it is then applied--the frog must first be placed in the water--to a woman while asleep, just at the spot where the heart is felt to beat, she will of a certainty answer truthfully any question put to her.--Pliny.



(Photos courtesy of the Corps of Engineers, Department of the Army)

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THE CONSTRUCTION of Conchas Dam on the South Canadian River in New Mexico was completed in 1939, and the reservoir was filled by June 1941. The area was opened for fishing in July 1941. At first the fishing was unusually good and, because of the scarcity of good fishing waters in that part of New Mexico and Texas, large numbers of people were attracted to the reservoir. This stimulated a considerable economic development for those who catered to tourists and for the suppliers of equipment, such as boats, motors, tackle, and bait. In the spring of 1946 the fishing began to slump and sportsmen complained to the New Mexico Department of Game and Fish.

For many years there has been in effect in New Mexico an understanding under which the Fish and Wildlife Service handles the propagation of warm-water fishes, such as bass and sunfish, and the State Department of Game and Fish propagates the cold-water species, such as trout. The Service often undertakes scientific fishery investigations at the request of the States,

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Since the preparation of this paper, Dr. Mottley has left the Fish and Wildlife Service, his resignation effective May 1, 1948.--The EDITORS.

but the actual management of sport fisheries is a State responsibility. The situation in New Mexico seemed to call for fundamental investigations. As the propagation of warm-water species was involved, the State asked the Service to make a study of conditions at Conchas Reservoir and to draw up recommendations for the improvement of fishing.

The Fish and Wildlife Service assigned the junior author, one of its fishery investigators, to the problem. Chamberlain spent the greater part of the 1947 fishing season at Conchas Reservoir, studying the situation. He was assisted in the field work by Mr. Elmo Traylor of the New Mexico Department of Game and Fish, whose intimate knowledge of the history of the fishing and conditions in the reservoir were of great value. The following report is based upon their observations and studies of the factors affecting the fishing. The information was obtained from interviews with fishermen, biological data collected in the field, stocking records, and pertinent data supplied by the Corps of Engineers, Department of the Army.

TABLE 1.--Fish planted in Conchas Lake, 1939 to 1946

Species	1939	1940	1941	1942	1943	1944	1945	1946	Total
Largemouth black bass	100,000		5,000	118,500	16,000	15,600	20,600	65,000	340,700[1]
Crappie	903	750	11,800						13,453
Pike perch		500,000	750,000						1,250,000
Bream			7,400	5,400		10,000	40,000	30,000	92,800
Green sunfish			43,600	11,000	2,160	57,411	4,822		118,993
Bullhead catfish						7,438			7,438
Channel catfish							853		853

[1]In addition, 45,000 largemouth black bass were planted in 1947.

THE CONCHAS RESERVOIR FISHES

At this point in the history of the Conchas Reservoir fishery, it is impossible to determine exactly what part the native species of the river have played in the development of the present fish populations. The stocking record has been reviewed to obtain the information here.

From the start, emphasis has been placed upon making the reservoir a bass lake. The stocking record is shown in table 1.

In addition, the reservoir was stocked in 1943 with a few pairs of adult gizzard shad. This was an extremely important addition to the number of fish species present, as will be discussed later.

An unpremeditated stocking of the lake appears to have taken place when a stock-watering tank washed out on a ranch near Springer, New Mexico. This tank held the mirror-scale variety of the common carp, which escaped into the South Canadian River. The great majority of the carp population of the reservoir belongs to this variety; so the association of these fish with those that were present in the tank appears indicated.

The species that have been mentioned cover all the important species found in the reservoir, but one or two species of buffalofish and several minnows are present also. The buffalo is usually found only in the rivers entering the reservoir, seldom being taken in the reservoir itself except immediately after high water in the rivers. The significance of the presence of individual species of minnows is probably not great. Minnows of a number of species are brought in by fishermen or minnow dealers for bait, coming from many waters within a radius of one or two hundred miles of the reservoir. Those not used by individual fishermen are often released within the reservoir, where they add to the list of forage fish present.

GENERAL HISTORY OF THE FISHING

The early history of the fishing at Conchas Reservoir is essentially the same as that of other warm-water impoundments. After Conchas Reservoir was opened to fishing in July 1941, game fish were readily caught with almost any form of lure or bait. Not only could the most inexperienced fisherman easily catch a limit of fish with the usual lures, but there were many reports of black bass caught with dried shrimp, pieces of rabbit meat, worms, and other bait not regarded as normally appealing to this game fish. White crappie were also caught easily and in considerable numbers. Unfortunately, there are no accurate records by which to judge the quality of the early fishing.

Mr. Traylor kept notes on the fishing for 3 months in 1947. Table 2 presents his estimate of the number of fish caught and the effort expended in catching them. The methods of fishing used for the three species listed are so different that estimates of the amount of effort expended can be given separately for each.

In order to judge the significance of the average catch of 0.22 fish per fisherman hour at Conchas Reservoir, it may be compared with similar estimates for other bodies of water. This comparison is shown in table 3.

It is apparent that the value of 0.22 fish per fisherman hour for Conchas Reservoir is at the low end of the scale, particularly when compared with the TVA reservoirs which have a similar type of fishing. It is difficult for anglers to reach an agreement on how big a catch would be considered as a "good" day's fishing, because so much depends on the size of the fish, the species, the method

TABLE 2.--Estimate of number of fish caught and effort expended during May, June, and July, 1947

Date	Species	Number	Weight (pounds)	Effort (fishing hours)	Number per hour
May 1947	Bass	600	1,650	4,000	0.15
	Catfish	200	500	800	0.25
	Crappie	450	500	480	0.93
		1,250		5,280	0.24
June 1947	Bass	350	600	2,800	0.12
	Catfish	400	800	1,000	0.4
	Crappie	250	225	200	1.25
		1,000		4,000	0.25
July 1947	Bass	200	250	1,000	0.2
	Catfish	600	1,600	3,900	0.15
	Crappie	100	100	100	1.00
		900		5,000	0.18
Three-month period		3,150		14,280	0.22

of fishing, the distance traveled to the fishing area, and many other factors. One fish an hour would be considered satisfactory by many anglers. In Conchas Reservoir it would take 4 or 5 hours, on the average, to catch a single fish. Most anglers would be likely to class the Conchas Reservoir fishing as poor in 1947. In seeking to find an explanation for this condition, the factors of the problem should be analyzed.

ANALYSIS OF THE PROBLEM

The quality of fishing in reservoirs may deteriorate for a number of reasons. Our immediate concern is to sort out from the many possible explanations the more plausible reasons for the slump at Conchas Reservoir, to see whether something can be done to remedy the situation. It should be emphasized that the fishing was once considered excellent, and that it changed to such an extent that it drew serious complaints from the fishermen. This change could be due to several factors:

1. A change in water conditions.
2. A change in the food supply.
3. A change in the habits of the fish.
4. A change in the stocking policy.
5. A reduction in the population, as a result of disease, predators, failure to produce sufficient young, or overfishing.

The procedure in the following paragraphs will be to discuss each of these factors to ascertain the plausible reasons for the slump, the findings to serve as a basis for recommendations for the improvement of the fishery.

Character of the Water May Have Changed

It is possible that there may have been a change in the character of the water in the reservoir, and this change may have had a detrimental effect on the fish. No evidence is available to show that there were any serious chemical changes. The amount of run-off has varied, and the water level has fluctuated from full reservoir height down to about 20 feet. The greatest reduction in water level did occur in 1945 and 1946. It may have had an effect on the breeding activities of the bass, or it may have seriously changed the amount of suitable bottom available for nest building.

A second factor that may have adversely affected the fishing in Conchas Reservoir, more particularly the bass fishing, was the severe wind that prevailed throughout the spawning season--and in certain years, as in 1947, during the entire fishing season. This second factor is regarded as the more serious of the two, for it is not subject to adjustment. Its effects are both direct and indirect. It interferes with fishing, with the distribution

TABLE 3.--Average catch of other bodies of water

Place	Average catch per fisherman hour
Four lakes in Wisconsin	0.81
Fife Lake, Michigan - 4 years	1.25
Chautauqua Lake, New York	0.55
A trout lake in California	0.21
An irrigation reservoir in British Columbia	0.77
Norris Reservoir (TVA) - 1938 and 1939	0.21
Norris Reservoir (TVA) - 1944, 1945, and 1946	0.42[1]
Wheeler Reservoir (TVA) - 1939	0.43
Wilson Dam Tailwater (TVA) - 1939	0.68

[1] Derived from the number of fish caught per trip, assuming an average of 6 hours fishing per trip.

of the bass population in the lake, and with the bass nesting and spawning activities (through muddied water, lowered water temperature, and destruction of nests by wave action). Before these adverse influences on fishing are considered, the record of these winds during the main portion of the fishing season should be noted. The information was furnished by the office of the Corps of Engineers at Conchas Dam. Their water temperature records from 1939 to 1947, inclusive, indicate that the effect of the wind in mixing the water of the reservoir has varied considerably from year to year.

Samples of the data of the Corps of Engineers are shown in table 4. Note the high temperature of the deeper water in 1941 and the small difference of only 2° F. between the temperature of the surface and the bottom. Compare this with the condition in 1942, when the difference between the surface and bottom temperatures was about 14° F. The data for 1941 are indicative of severe wind action; those for 1942 suggest that more moderate winds have prevailed. The records for 1947 have been studied in more detail and are discussed in the following paragraphs.

All lakes and reservoirs are subject to a certain amount of windy and breezy weather. Because of the location of Conchas Reservoir in country with much the same set of conditions as in the nearby Panhandle of Texas and Oklahoma, a region noted for its severe and extended winds, Conchas Reservoir is exposed to much more wind than the average reservoir. On not 1 day during April 1947, did a column of less than 100 miles of air move over Conchas Reservoir in any given 24-hour period; the average for the month was 256 miles of air per day. In May there was only 1 day when the column of air that flowed over the reservoir was less than 100 miles long, and the average for the month was 186 miles. The average for June was even higher than for May. June had only 1 day with an air flow under 100 miles, and its average was 212 miles. July had the lowest average of the fishing season, but it showed a very slight let-up, for the average was 149 miles: only on 2 days in July did the figure stand at less than 100. On 5 days during August the length of the air column that passed over Conchas Reservoir was less than 100 miles long, but the average for the month was higher than for July, standing at 159 miles. For September, the last month for which the data were studied, the wind had increased to an average of 184 miles per day. The total movement of air for the full 6-month period from April to September, inclusive, was 29,893 miles, an average of 163 miles per day.

The averages shown do not give more than a part of the picture, for the wind was never steady long; it varied from an occasional few hours of calm to many hours of severe activity that threw up 6-foot or higher waves on the reservoir. Winds of any force tended to interfere with actual fishing by making it difficult or impossible except in limited protected areas. In addition, the winds had serious indirect effects on fishing. Probably the most important of these was the lowering of water temperatures in the commonly fished shallower areas and at the water

TABLE 4.--June water-temperature records for Conchas Reservoir

1941		1942		1947	
Depth (feet)	Temperature (degrees F.)	Depth (feet)	Temperature (degrees F.)	Depth (feet)	Temperature (degrees F.)
0	65.0	0	72.6	0	70
15	64.8	5	71.7	15	69
35	64.0	25	70.5	25	68
55	63.4	45	63.3	45	66
75	63.1	65	59.7	65	60
95	62.1	85	58.3	90	58
115	62.8	105	57.9	110	58
135	63.0	125	58.5	120	58

surface of the main reservoir. Further, wave action tended to stir up mud and silt within the range of such effects by the waves. Whatever the reason, the fishing for bass was not usually successful during the periods when strong winds prevailed.

The lowering of water temperatures in the reservoir through wind action is due to the water turn-over that occurs when the wind is sufficient to make the waves run high. Cold water is brought up from below, and the warmer surface water of the summer months is dispersed into the depths. This was brought out by the temperature determinations made of surface water and of water drawn from outlets in the face of the dam down to 70 feet below the surface. Rarely did a week pass, before July, without at least one windy period severe enough to mix the reservoir water to a depth of 50 to 70 feet.

The temperature at which largemouth black bass will spawn may vary slightly in different waters, but nest-building usually begins when the temperature reaches about 65° F. Spawning begins at about 68° F., but it requires several days of steady temperature. Other factors being favorable, nesting bass require about 5 days to complete their activities. As some bass are slower getting started than others, fish-culturists hope for a period of at least 2 consecutive weeks with the water at 68° or higher to assure a successful spawning season for bass.

The water-temperature history of the Conchas Reservoir for 1947, in the greater part of those limited areas of the reservoir where conditions for bass spawning might be considered satisfactory, was not such as to give assurance of a successful spawning season for bass. This was because the churning action of the wind caused the temperature of the upper layer of water and (through the currents produced) that of the water in most of the shallower sections, continually to drop below the bass spawning temperature range after having risen into it. There is evidence that again and again spawning activities of the bass would be begun, only to be discontinued. Many female bass were ready to spawn as early as April, yet continued to hold their eggs more or less indefinitely. Many were still holding their eggs in July. At least a portion of the egg masses examined at that time gave the appearance of having been held in a ripe condition too long--in other words, of having spoiled. It is known that Centrarchid fishes (to which family the black bass belongs) may not spawn in certain years when conditions are not right, but instead absorb their eggs.

A review of the temperature data indicates that temperature conditions were definitely adverse for spawning in 1941. This may have lowered the production of young that year with serious repercussions for several years. On the basis of the temperature records of the past 9 years, it appears likely that adverse wind conditions may interfere with bass spawning about 1 year in 3.

Food Supply for the Game Fish May Have Changed

The food supply is a very important item in the production of sport fish. In the first place, enough food of the proper type is needed for the game fish to grow to a desirable size. Furthermore, there should be sufficient food to support a population great enough to supply a satisfactory number of strikes per unit of fishing effort. On the other hand, if the food supply is too great and the fish population too small, the number of strikes may be reduced to a point where fishing is regarded as unsatisfactory.

There is not enough evidence to reconstruct the early history of the food situation in the reservoir. It seems likely that the first planting of bass was highly successful and that the reservoir became overpopulated in early years. Undoubtedly, the bass were being supported by crappie, sunfish, and their own young. Experience in the management of farm ponds has shown that such combinations may easily get out of balance.

A few adult gizzard shad were planted in 1943. By 1946 the gizzard shad had increased to such an extent that schools of them were being noticed by fishermen and specimens were being observed in the stomachs of the bass. Very large schools were seen in 1947. The biologists investigating the TVA reservoirs have found

that the gizzard shad forms the basis for their game-fish production. The gizzard shad is an ideal forage fish for impoundments. It is very prolific; its reproduction is not seriously affected by fluctuating water levels; it feeds on the floating plants and animals of the open water, so that it does not compete with the game fish.

It appears likely that in Conchas Reservoir the gizzard shad has flourished to such an extent that it now provides an ample food supply for the game fish. It is possible that the reproductive rate of the bass may not be great enough to produce a sufficient number of young to utilize the food potential of the situation. The rate of growth, as shown in table 5, is much better than that for largemouth black bass in the majority of lakes.

Habits of the Game Fish May Have Changed

The fishermen have reported that the bass have changed their habits. Formerly the bass were caught in great numbers in the vicinity of submerged trees. The bass were evidently feeding on the crappie, which have a habit of gathering around brush shelters. With the advent of the gizzard shad, the feeding habits of the bass have changed. They are now more dispersed in pursuit of the gizzard shad and are scattered to a much greater extent throughout the reservoir. This dispersion is also intensified when heavy winds mix the water. In the years when the wind action was more severe, as it probably was in 1946 and 1947, the bass did not congregate so readily near the surface. These changes in their habits undoubtedly affected the fishing. It may take time for the anglers to develop appropriate fishing methods.

Stocking Policy May Have Changed

The policy of the Fish and Wildlife Service, with respect to the stocking of warm-water species, has been to use its facilities for the introduction of fish. The Service does not attempt to maintain stocks of fish in large bodies of water like Conchas Reservoir by annual plantings; indeed, to attempt such a program would require a very large outlay. The stocking record for Conchas Reservoir shows that the Service has not attempted a large-scale maintenance program. It does not seem likely that the variations in the number of the different species planted since 1939 have had much to do with the decline in the fishing.

Populations of Game Fish May Have Been Reduced as the Result of Disease, Predators, Failure to Produce Sufficient Young, or Overfishing

There is no evidence of a sudden mortality of the game fish in Conchas Reservoir as the result of disease or suffocation. As this report was being written, word was received that large numbers of gizzard shad died in February. This phenomenon occurs in Norris Reservoir each winter.

Most of the warm-water game fish prey on their own young. Probably the most severe cause of reduction of the bass population is cannibalism.

Large numbers of mergansers winter on Conchas Reservoir. It was not possible to make a thorough investigation of the relationship of these birds to the fish population. From studies made elsewhere by other workers, it has been concluded that the mergansers do not seriously harm the game fish. In some situations, such as Illinois and the TVA reservoirs, the fishery biologists believe that the mergansers or other fish-predator birds actually perform a useful function. They feed predominantly on the nongame fish and keep them under control.

One of the most important of the considerations regarding the reduction of the population is the question of the ability of the bass to produce sufficient young from year to year to provide satisfactory fishing. Table 5 shows that all the age classes since 1939 were represented in the catch in 1947. It is possible that the fluctuations in water conditions may lower the production of young in certain years and that the reproductive capacity of the bass population is generally at a low level. These questions can be answered satisfactorily only by a carefully designed test-netting

TABLE 5.--Largemouth black bass taken from Conchas Reservoir, 1947

Year		Number examined	Average length (inches)	Average weight (pounds)
One	(1946)	16	10.7	0.65
Two	(1945)	58	13.4	1.33
Three	(1944)	57	16.2	2.68
Four	(1943)	54	18.1	4.33
Five	(1942)	20	20.6	5.42
Six	(1941)	7	21.3	6.35
Seven	(1940)	2	23.0	7.25
Eight	(1939)	1	23.5	7.75
		215		

program to determine the relative abundance of the different age classes of the bass as well as of other species.

From the observations on the fishing, it does not seem likely that Conchas Reservoir is being overfished. The total production for 1947 was probably less than 5,000 individual game fish, not counting the sunfish. This means that the fish crop was less than 1 fish per acre, which is an extremely low figure for waters of this type.

The conclusions reached in these foregoing sections indicate that the water conditions in Conchas Reservoir may seriously curtail bass production. The slump in the fishery may have been due to the coincidence of a poor production of young and a change in the feeding habits of the bass--as a result of the introduction of the gizzard shad--so that the bass were less available to the fishermen. It seems likely that there may be frequent depressions in bass production until a larger population of older fish is built up to provide a reserve. An increased population would also bring the numbers of gizzard shad into a better balance with the game fish. The die-off this past winter may help in this direction.

RECOMMENDATIONS

The question to decide now is what can be done to improve conditions. There are four things that are usually considered under such circumstances.

1. Improve the habitat.
2. Decrease the numbers of undesirable species.
3. Increase the numbers of desirable species.
4. Introduce new species better adapted to the conditions.

There is little that can be done immediately to improve the habitat for bass spawning. Subimpoundments to provide more sheltered nesting areas might be considered. The Corps of Engineers should be alerted to the need for maintaining steady water levels, particularly at the time in spring when the surface water reaches a temperature of 68° F. and stays there for a few days. This should help to prevent the exposure of bass nests in shallow water to wave action.

There does not appear to be an urgent need for control operations for undesirable species. The carp seem to have passed through a cycle in which they multiplied beyond their food supply. These fish may be detrimental to bass production through disturbance of the nesting areas. The shores of the reservoir are too rocky and the underwater areas have too many snags for a profitable commercial fishery for carp. If subimpoundments are built, the danger of having carp take them over should be kept in mind.

The problem of increasing the numbers of desirable species is a difficult one. Under such circumstances most people immediately suggest hatchery operations. A study of results likely to be achieved,

however, will reveal that hatchery operations will not provide much improvement. The difficulty is that hatchery plantings are usually measured in terms of thousands of eggs. After a stock of bass has become established in a lake, the size of the planting should be judged by the number of nests that it represents. For example, a planting of 100,000 fingerling bass may be equivalent to only 20 or 30 nests and ultimately less than 100 additional adults. In a lake the size of Conchas Reservoir, this would not make an appreciable difference to the total stock. Hatchery operations would have to be conducted on a tremendous scale to increase the stock in off years. In good years hatchery operations would not be warranted. The cost of such an undertaking would be beyond the present means of the Fish and Wildlife Service.

It has been suggested that certain areas might be closed off, as the Canadian Arm was for several years. This procedure merely concentrates the fishing in the open areas and probably has very little effect in the long run. It is not recommended for general use, except for protecting limited spawning areas.

Eventually the bass population may reach a better balance in which there will be a greater number of individuals in the older age classes. This reserve will make less obvious the fluctuations in the fishing, especially if the production of young is lowered by adverse conditions in certain years. Conchas Reservoir is so new that it will take several years before the various populations of fish reach stability.

The best policy seems to be to accept the conditions in the reservoir as they are and to introduce or foster the species of fish that are better adapted to them. The yellow pike perch was introduced, but in this reservoir there are two main drawbacks: the deep water of the reservoir is so full of snags that fishing is difficult; the spawning areas are inadequate. In 1947 a few rainbow trout were planted to see whether they would survive. The difficulties that pertain to the yellow pike perch apply also to the rainbows: fishing in deep water will be difficult, and there are no spawning grounds; expensive hatchery operations would be required to maintain the stock at a level high enough to support fishing satisfactorily. The deep water may also be too warm in years when heavy winds prevail.

There is one species which is proving highly successful in impoundments, such as Lake Texoma on the border between Oklahoma and Texas. This is the white bass, which is related to the ocean bass. The white bass does not build nests but spawns in the more open water. It feeds on the gizzard shad and may reach a weight of 2 or 3 pounds. There is no assurance that the white bass will flourish under the conditions at Conchas Reservoir, but it should be tried.

The following actions are specifically recommended:

1. The possibility of the construction of a subimpoundment for an experimental bass nursery area should be explored with the Corps of Engineers.

2. The Corps of Engineers should be informed of the danger to the survival of young bass if the water level is lowered during the nest-building and spawning season.

3. When any new reservoirs are to be stocked, a definite stocking schedule should be drawn up in advance. It is suggested that the forage fish be introduced at the time the reservoir begins to fill and that the number of game fish to be planted be scheduled on an increasing scale for the first 3 years. For example, if the suggested policy were followed, Conchas Reservoir would have received a planting of adult gizzard shad and about 50,000 fingerling bass in 1939; in 1940, another planting of gizzard shad and 100,000 fingerling bass; in 1941, about 150,000 fingerling bass.

The same policy would apply to the schedule of introduction for the other game fish desired. No further stocking of these species should have been required after 1941. Some attempt should be made to inform the sportsmen who fish Conchas Reservoir of the relative cost of introducing fish according to a planned schedule as compared with operations to maintain a stock at a high level by artificial propagation. The former is possible with existing funds and facilities, but the

cost of the latter is prohibitive.

4. An experimental introduction of the white bass should be made to determine whether it is suitable for the conditions in the reservoir, and whether it will make a significant and useful contribution to the game-fish crop.

5. The Conchas Reservoir fishery is so important for the people of the region that steps should be taken to answer the more urgent management questions. A creel census should be taken to provide accurate data on the production of game fish. A test-netting program should be planned to measure the abundance of the age classes of the different species. Such operations will be needed to determine the success of the planting of white bass, to forecast future fishing conditions, and to provide the information necessary for the management of the fishery.

If an acre will produce 150 pounds of beef, increasing the number of cattle to the acre will not increase production. The same holds true for fish.

BANGOS CULTURE IN THE PHILIPPINES

W. F. Carbine
U. S. Fish and Wildlife Service
Manila, Philippines

THE MOST popular dish of millions of people in the Philippine Islands is a pond-reared fish known as the bangos to the Filipinos of central Luzon and as milkfish to the Americans. The bangos outranks all other species of fish in total production within the Philippines and is a fine example of practical fish culture on a commercial scale. The popularity of the bangos as a market species is due to its palatability and dependability as food. The bangos appeals to the fish-culturist because it is fast growing and noncannibalistic. To the public, the bangos is a food available--as a result of being under controlled production--when all other sources of fish fail; to the culturist, it is a steady and profitable source of income. From an over-all economic viewpoint, the bangos industry is important because it makes use of thousands of acres of otherwise practically valueless land. In addition, many people derive their sole livelihood from one or another of the phases of this industry. Probably the most important feature of this enterprise, however, is the fact that relatively few fish of the species would be available for human consumption if it were not for fish-cultural activities, as this species is seldom encountered at sea and apparently only part of the population enters rivers and estuaries.

The information for this report has been obtained from a number of publications listed at the end of this paper, and from experiments, observations, and interviews obtained by the writer during more than 12 months' residence in the Philippines.

Since the preparation of this report, Mr. Carbine has been transferred to the central office in Washington, D. C., where his new assignment will be in the Branch of Fishery Biology.--The EDITORS.

DESCRIPTION AND RANGE

The bangos (Chanos chanos) is the only living member of the family Chanidae. It is a herringlike fish with a single, soft back fin, a deeply forked tail, a small and toothless mouth, and a body covered with smooth scales. It is found throughout the warm waters of the Pacific and Indian Oceans, from southern Japan to Australia and from southern California and Mexico to the Red Sea. It is an important food fish over most of its range.

LIFE HISTORY

The bangos is a fish of the open sea and a swift and powerful swimmer. The adults, which may reach a length of 5 feet, seldom enter shallow water except during the spawning season, at which time some of them are caught in nets and fish traps. The bangos is capable of making tremendous leaps out of the water, and it is said that a 3-foot bangos can easily jump a distance of 30 feet while clearing obstructions 6 to 12 feet above the surface of the water.

Bangos fry and fingerlings often enter fresh-water rivers, and a few individuals may find their way into lakes. These fish may grow to a large size in fresh water but never reach sexual maturity there and must return to the ocean to spawn. Experiments conducted by fishpond owners have failed to produce sexually mature bangos in ponds.

Very little is known of the life history and habits of the free-living bangos. Females are said to contain between 1.5 and 7 million eggs. It is not known whether the eggs are pelagic or demersal. According to the literature, the spawning season extends from March to June or July, but we now know that bangos fry can be obtained in certain localities in the archipelago during most of the year (all months except perhaps December).

Bangos fry 10 to 13 millimeters in length (0.4 to 0.5 inch) are found near shore. They enter estuaries and tidal streams during the advancing flood tide. It is said that they are most abundant 3 days before and 3 days after full moon, although they are common at every high tide and small numbers may be obtained at all times of the day or night from March through July at least. Not much effort is made to collect fry at other times of the year. Because of the greater abundance of fry at high tides, it may be inferred that the spawning of bangos may be regulated by, or at least associated with, the tidal cycle.

Bangos fry begin to feed when the yolk sac is absorbed (when the fry are between 12 and 15 millimeters in length), and their first food in ponds consists of blue-green algae and associated organisms which Filipinos call lab-lab (pronounced "lub-lub"). When the fry are between 50 and 75 millimeters (2 to 3 inches) long, the food preference begins to shift to filamentous green algae known as lumut.

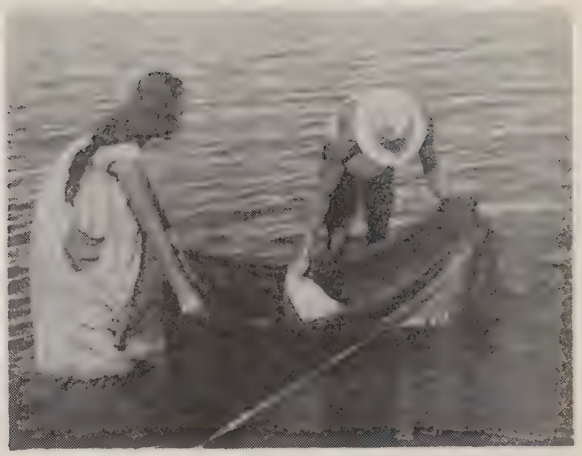
HISTORY OF BANGOS CULTURE

The culture of bangos has been carried on for more than 500 years in Java, where laws codified in 1400 A.D. protected fishpond owners. It is impossible to say when fishponds were first constructed in other localities, but the bangos culture of today is the result of a gradual development over a period of many centuries. The first ponds were merely fish traps made by constructing a dike across the narrow entrance to a bay or inlet. A gate was constructed to allow an interchange of water, permit the entrance of fish carried by the incoming tide, and prevent their exit. It is quite obvious that the results obtained by this method were altogether a matter of chance. Predatory fish admitted soon reduced the numbers of fish present, and the owner of such a pond never knew until the day of draining just how many fish were in the pond. The greatest development of ponds of this type took place in Java, the Hawaiian Islands, the Philippines, Madura, Formosa, and other parts of southeastern Asia. Some ponds of this type are still in use today in all countries in which bangos culture is practiced.

Eventually, people in the more advanced regions ceased to stock their ponds by chance and an enormous fishpond industry came into existence around such favorable localities as Batavia and Surabaya in Java, Madura, Singapore, and Manila. Young bangos, mullets, and at times other species of fish and shrimps were caught along the coast and placed in ponds. No other care was given them, and the presence of predators kept production low.

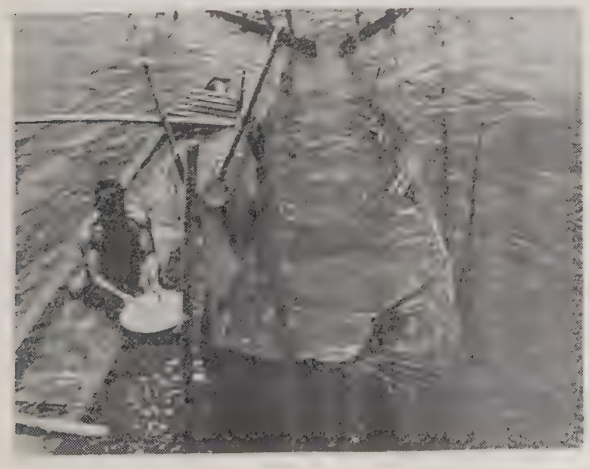
The culture of bangos as a specialty has received the greatest impetus and reached the greatest development around Manila Bay in the Philippines. This is probably due to two factors: the peculiar location of the Philippine Islands with respect to the prevailing monsoons and the protracted periods of inclement weather (during the southwest monsoon, which

Man and woman (white-enameled basin on head) using sinamay-cloth seine.



Taking fry from seine with white-enameled basin.

Sorting fry. Those other than bangos are dumped on ground to die.



Bangos fry trap, the bag made of sinamay cloth.

Unglazed earthenware jar, containing fry, ready for shipment.

occurs from the middle of June to the middle of October) during which coastal fisheries may not be operated and the bangos is the only fresh fish available in the markets. Fish and rice are the staples of the Filipino diet, and the large population in the Manila region depends to a great extent upon bangos for the daily source of animal protein. During the southwest monsoon, this demand is intensified.

SPECIALIZATION IN BANGOS CULTURE

The extent and intensity of the industry are illustrated by the fact that at least three highly specialized phases have been developed. Separate occupations deal with catching fry, raising fry to the fingerling stage, and raising fingerlings to marketable size. The most noteworthy of these is the collection of fry.

Another very specialized aspect of bangos culture has been developed in the vicinity of Dampalit, north of Manila, where culturists owning hundreds of ponds hold large numbers of fingerlings in special nursery ponds with an ample supply of brackish water but very little food for periods of 6 months to a year. During the season when fry are scarce or unobtainable, these culturists sell the "stunted" fingerlings to other pond owners who have just harvested one crop of bangos and desire to produce another without delay.

BANGOS FRY INDUSTRY

All bangos culture is dependent upon fry taken from the shores of the sea. Each season certain coastal municipalities lease the best collecting grounds to the highest bidder. The thousands of men, women, and children who collect the fry for the lessee are paid from 5 to 25 centavos (current exchange rate of 2 pesos to one U. S. dollar) per hundred fry, depending upon the season and the demand. There are no laws limiting the number of fry collected or the method of collection. Some very wasteful procedures are followed, resulting in the loss of many millions of bangos fry and the fry of other species associated with bangos.

Bangos fry are captured in nets of sinamay cloth (Manila hemp, about the same mesh as fine cheesecloth) formed into seines, traps, and dip nets. Seines, usually 5 or 6 feet deep and 15 to 20 feet long, are used in shallow water, near shore. The fry trap (saplad) is a V-shaped barricade of lengths of crushed bamboo fastened to stakes in the mouths of rivers, estuaries, or tidal streams. At the apex of the "V" there is attached an open bag made of sinamay cloth approximately 2 feet wide and 6 or 8 feet long. Fry brought in by the advancing flood tide are carried into this net. A number of fry traps may be used to cover the entire width of a stream. Dip nets, of various sizes and shapes, are operated near shore in shallow water and near the banks of streams and canals.

The bangos fry are dipped from the seine, trap, or dip net with a white-enameled basin. Debris is removed, and the bangos fry are sorted from the fry of other species by dipping a few fry at a time from the basin with a clamshell or small saucedish. Fry and small fish of other species are usually dumped on the ground to die rather than returned to the water. Many of these are the fry of valuable fish, but others are definitely "trash." After being sorted, all bangos fry are placed in unglazed earthenware jars (20- to 30-quart capacity, holding 2,000 to 3,500 fry each).

Collectors seldom count all the fry in each jar. The usual procedure consists of counting the fry in one jar and estimating the number of fry in the other jars by comparing densities. Experienced men are extremely good at estimating the numbers by this method. Fry may be held in jars as long as 14 days, sea water being added daily. Some dealers that move fry inland may add fresh water to the jars.

Bangos fry are moved as much as 500 miles by truck, train, and ship. Great losses sometimes occur because of breakage, overcrowding, predators, lack of oxygen, high temperatures, and spillage.

Although some dealers make a conscientious effort to remove all foreign species usually associated with the bangos, other dealers do not; so most buyers must sort the fry before planting. Even when great care is taken, some undesirable species

are overlooked and are planted. At least 76 different species of fish have been collected from bangos ponds. Of course, many of these species enter the pond when fresh sea-water is added--screens usually are made of split bamboo and are not fry-tight--but many are inadvertently planted along with the bangos fry.

The demand for bangos fry is much greater during May and June than during other months. There are times, therefore, when dealers are unable to sell their fry and many are lost. Most dealers, however, have tie-ins with wholesale fingerling-culturists who have nursery ponds available for rearing the fry that cannot be sold.

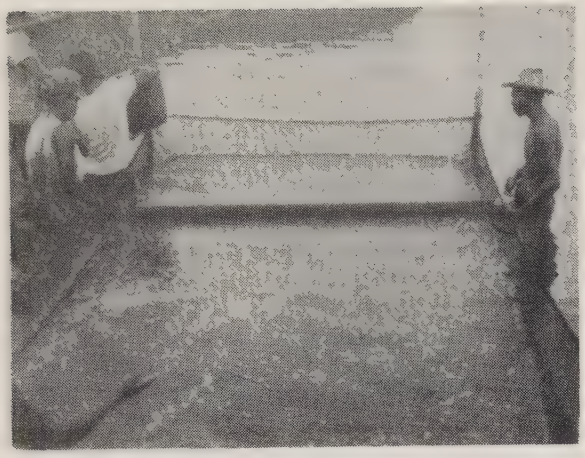
LOCATION AND CONSTRUCTION OF PONDS

Along the coast in many localities in the Philippines there are large areas of swampland and tidal flats, suitable for fishponds. In many sites no excavation or filling is necessary in order to make a pond of any size desired. All that is needed is a dike to surround the area. In the Philippines several ponds that have an area of more than 1,000 acres are built in this way. Clay (peaty clay or colloidal clay with or without organic matter) is the most desirable soil for pond bottoms and for building dikes; therefore, peat or tule land is best for fishponds because the soil is right and no clearing is necessary. Nipa palm land is next best. Mangrove swamps, though extensively used for ponds, are more expensive to clear because the trees are larger, the hard wood is more difficult to cut, and the stumps are harder to remove; but once removed, mangrove wood is in great demand for firewood and the bark for "cutch," used for tanning fish nets and leather. Fishponds are usually constructed near a deep tidal stream to insure a plentiful supply of brackish or salt water, as the water levels of all bangos ponds are tide-controlled. The bottom of a pond is always higher than mean low tide so that the pond can be completely drained.

All construction work is done by hand labor. In digging mud for building dikes, excavating, or filling, a small spade-like instrument is used and the soil in the bottom of the pond, river, or estuary is removed in blocks. Each block is placed in a banca (native dugout canoe), which, when filled, is paddled to the construction area. The mud is then transferred by hand and dropped in the spot where needed. Dikes are always built in a series of layers, each of which is about 2 feet thick. Each layer is allowed to dry for several days before the next layer is placed on top. Mangroves and nipa palms are sometimes planted along the exposed sides of dikes to prevent damage by wave action, current, and other types of erosion. The bottom of a pond is prepared so that it drains readily toward the outlet, and large ponds may have several channels to facilitate drainage. Dikes vary in height, depending upon the tidal variation at each particular location.

Sluice gates, to control the inflow and outflow of the water in each pond, are usually built of concrete, although stone and wooden gates are still in use in many places. Each sluice gate can be fitted with screens at either end, and flashboards usually fit in grooves in the center. The depth of water that can be maintained in a pond depends upon the height of the tide. Screen frames are usually fitted with pieces of split bamboo about 1/8 inch in diameter and spaced between 1/8 and 1/4 of an inch apart. Sinamay cloth is frequently used to cover the screens in fry ponds in an effort to prevent the escape of bangos fry and to keep out undesirable fry whenever the water is changed.

In pond systems where complete pond-fish culture is practiced, the ponds are of three different sizes, each used for different-sized fish. The smallest ponds (0.1 to 2 acres) are the nursery ponds used for fry culture. Ponds intermediate in size between the nursery and rearing ponds (approximately 1 to 4 acres) are used for rearing fingerling fish. Rearing ponds, which vary greatly in area, are used to raise fingerling fish to marketable size. Some pond owners raise bangos fry only to the fingerling stage, and these people use nursery ponds. Other pond owners have only rearing ponds, buying the fingerling fish which they raise to marketable size.



Fish are placed in seine, then driven to one end with bamboo pole.

Fish are divided into equal portions with another bamboo pole.

COUNTING FINGERLINGS

MOVING AND HANDLING METHODS

Some people own several thousand acres of bangos ponds. These big operators, and those who specialize in raising fingerlings, must move their fish a considerable distance before stocking. Fingerling bangos are removed from the catching pond in pails and placed in large bancas (either native dugout canoes or large bancas made of planks). Two or more screened holes in the bottom of the banca provide for circulation of water. A man standing or sitting in a screened box in the center of the banca bails water to prevent the banca from sinking. The banca is poled or towed to the rearing ponds where the fish are planted.

The fish are usually left in each of the different ponds until all the food is consumed. At certain times, however, fry and/or fingerlings may have to be transferred from pond to pond of the same size because of a lack of food. Bangos-culturists seldom, if ever, feed artificial food. When food is scarce, some operators will bring in several banca-loads of lumut. Specialized fingerling-culturists sometimes feed their "stunted" fish rice bran. Fish usually are from 2 to 4 inches long when removed from the nursery pond, 4 to 8 inches long when removed from the fingerling pond, and from 7 or 8 to 15 or 18 inches when marketed, depending upon the amount of food, the number of fish in a pond, the cultural system practiced by the owner, and the demands of the market.

A special catching pond is often constructed to take advantage of the instinct of the bangos to swim against the current. Fish are moved when the food in one pond is exhausted or when it is desired to take them to market. In ideally constructed pond systems, each pond or perhaps every two ponds are provided with these catching basins. Each catching pond is provided with two sets of sluice gates, one leading to the supply canal and the other to the rearing pond. At low tide, the water level of the rearing pond is lowered. At high tide, water is admitted to the rearing pond via the catching pond, where the screen and flashboards are removed from the sluice gate separating the two ponds, and the bangos then move from the rearing pond into the catching pond, where they are captured for removal. In other pond systems, the nursery, fingerling, and rearing ponds are placed in a series so that fish can be transferred from one to another by opening gates and admitting water.

A unique method of counting fingerlings has evolved. The fish are removed from the catching pond by means of seines and dip nets and placed in a large, rectangular, fine-meshed cotton seine partly submerged in the water and supported at each corner by a bamboo pole driven into the bottom. A bamboo pole is placed under the net, and all fish are gradually worked

Foreman "feels" density in each portion, may transfer some fish to equalize

When the foreman is assured of equal division, fish are removed with pails.

COUNTING FINGERLINGS

toward one end of the net. Another bamboo pole is now inserted under the net and used to divide the fish into two equal portions. The experienced nurseryman (usually the foreman) makes certain that equal numbers of fish are present in each half of the net, thrusting his hand into each subdivision to judge the density by "feeling" the fish. The foreman also compares the densities of the fish in the two subdivisions by observing the number of fish in each. If the foreman is not satisfied that the fish are equally divided, some are transferred from one half of the net to the other. When the foreman is satisfied that the fish are divided equally, all fish in one half of the net are moved to a pond or to a banca for transfer to another pond. The fish remaining in the net are divided again. This process is continued until there remain just a small number of fish, which are easily counted. If the number remaining represents 1/8 (or 1/16 or 1/32) of the total, the number counted is multiplied by 8 (or 16 or 32) to obtain the number of fingerlings originally placed in the net. The writer has seen more than 250,000 fish "counted" in this manner at one time. When fingerlings are sold, the buyer attempts to outsmart the seller by choosing the half to be transferred each time. If the buyer can pick out the bigger half each time, he gets more fish for his money, whereas the seller loses money. Actually, all these men are experienced and it is doubtful that either buyer or seller makes any big mistake, especially when fingerlings sell for $200 or $250 for every 10,000.

RATE OF STOCKING, GROWTH, AND MORTALITY

Nursery ponds are stocked at the rate of 120,000 to 200,000 fry per acre. Mortality of the fry varies between 10 and 40 percent during the 4 or 5 weeks that the fry may be in the nursery pond. Under average conditions, fry grow at a rate of better than 1 millimeter per day and at the end of their first 4 or 5 weeks in the nursery pond will average 2.0 to 2.5 inches in length.

The number of fingerlings stocked per acre varies greatly, but usually all the fish removed from the nursery pond are placed in the fingerling pond if a good growth of algae is present. Growth of fingerlings continues at a fairly rapid rate as long as the food lasts.

Rearing ponds are usually stocked with about 400 fingerlings per acre, but the rate of stocking varies greatly, depending upon the amount of food, the size of pond, and the individual operating the ponds.

The estimated mortality from the fry stage to marketable size may be as high as 70 percent.

The time of harvesting and the size of fish at the time of harvest vary according to the management methods followed

Spades and bancas used in digging and transporting mud for dike.

Banca loaded with mud being moved to site of dike.

CONSTRUCTION OF DIKE

and the condition of the market. Bangos are usually marketed after they have reached a weight of about 1 pound. Six to nine months are sufficient to grow fish of this size. After the fish have been marketed, the rearing pond is drained and dried and a new growth of lumut is started. When a sufficient quantity of lumut is present, the pond is restocked with fingerlings. In this manner, it is possible to produce three crops of marketable-size bangos in 2 years in average ponds, two crops a year in good ponds that are well managed, and as many as three crops per year in exceptional ponds such as those operated by the National Development Company of Capiz, Panay Island.

FEEDING HABITS

Very little appears to be known about the actual feeding habits of bangos during the various stages of development. According to the literature, bangos are vegetarians, subsisting upon lab-lab, lumut, and digman.

Lab-lab is the Tagalog name given to the plant complex composing the food of small bangos from the fry stage until they reach a length of 2 to 4 inches. In properly prepared ponds, lab-lab forms a dense mat over the entire floor of the pond. Lab-lab is composed of unicellular, colonial, and filamentous blue-green algae (chiefly of the family Oscillatoriaceae), diatoms, bacteria, protozoans, entomostracans, and a small amount of filamentous green algae.

Lumut is the Tagalog name applied to filamentous green algae, the food of larger bangos (more than 2 to 4 inches in length). Lumut consists primarily of Cladophora, Enteromorpha, Vaucheria, Spirogyra, Chaetomorpha, and Oedogonium. It appears in the pond as dense mats of floating green scum.

Digman is the Tagalog name given the submerged leaves of the higher rooted aquatic plants which grow in some ponds and which may be eaten by larger bangos. The genera most commonly found in bangos ponds are Ruppia, Halophila, Najas, and Thalassia. Some of these aquatic plants grow better during the rainy season, when the salinity is low; other species grow better in salt water. Duckweed (Lemna) is also found in some ponds during the rainy season. Most species of higher aquatic plants are not present in bangos ponds that have a luxuriant growth of lumut. The higher plants begin to appear only after most of the algae have been consumed; therefore, the presence of digman in some ponds may be a sign of "overgrazing"--too many fish for the amount of food available.

GROWTH OF ALGAE

In bangos culture, both qualitative and quantitative aspects of the growth

Laborers removing mud from banca at site of dike.

Repairing dike. Banca in supply canal. Bangos ponds in background.

CONSTRUCTION OF DIKE

of algae appear to result from the influence of the following four factors: nature of the bottom, depth of water, salinity, and proper preparation of the pond before stocking.

Nature of the bottom.--The few soil analyses that have been made indicate that the production of fish and algae is best in ponds having a high solution loss (obtained by treating a sample of soil with hydrogen peroxide and washing), high content of clay, nitrogen, and organic matter.

Depth of water.--A maximum depth of not more than 4 to 5 inches of water is maintained in nursery ponds because experience has shown that lab-lab grows best in shallow water. After the nursery pond has been dried, water is added until the bottom is covered. When the mat of lab-lab appears on the bottom, water is added gradually until it is 4 to 5 inches in depth. Fingerling ponds are treated in the same manner, but a slightly greater depth of water (6 to 10 inches) is maintained. It is necessary to have both lab-lab and lumut in the fingerling ponds because at first many of the fingerlings are too small to feed on lumut. Rearing ponds contain a greater depth of water (up to 3 feet or more, depending upon the height of the tide). Although the difference in the water level maintained in nursery and rearing ponds may not be great, it is possible that the difference in light penetration or water temperature may contribute to the differential production of lab-lab and lumut. It is well known that the same pond can be used to grow lab-lab and later lumut, just by regulating the water depth.

Salinity.--Bangos can live in either salt or fresh water. It is known that the various components of lab-lab and lumut have different salinity tolerances and that the composition of each association at any time depends upon the salinity of the water, which varies from pond to pond and from season to season. Bangos-culturists claim that a brackish water supply is superior to either straight fresh-water or straight salt-water and that bangos grow best during the rainy season when the salinity is low.

Preparation of the pond.--Bangos ponds are usually drained and dried for several weeks before being refilled with water, and a good growth of lumut and lab-lab is established before the pond is stocked with fish. Popular opinion here and elsewhere maintains that undrainable ponds are virtually worthless for raising fish. If proper drying is not performed, or if bangos are planted before a luxuriant growth of algae is obtained, the fish do not grow well. Bangos-culturists claim that drying the ponds is necessary to kill the enemies of the bangos and to produce a good growth of lab-lab and lumut. What actually happens is not known, but it must be that the aerobic processes caused by the drying result in the oxidation of organic matter and the consequent liberation of plant nutrients. Experiments

elsewhere have indicated that drying of pond bottoms raises the pH of pond bottoms, controls higher aquatic plants with heavy root systems, reduces concentration of bacterial parasites, and encourages nitrogen fixation by blue-green algae and bacteria.

The addition or replacement of water is necessary for proper pond management. The continual use of ponds would progressively rob the pond soils of their fertility if it were not for the practice of admitting water at high tide. Most rivers flowing through towns and villages are heavily polluted by sewage. The repair of eroded dikes with rich river-bottom mud also helps to maintain pond fertility. At present no artificial fertilization is practiced.

There are still available in various parts of the Philippines extensive areas of nipa and mangrove swamps totaling more than 430,000 hectares. These areas are on the public domain at present and are utilized only for gathering firewood, nipa shingles, and the sap of the nipa palm, which is used to make vinegar, alcohol, and tuba (a mild, slightly alcoholic brew made by fermenting nipa palm juice from 12 to 48 hours). At present the government is interested in the immediate utilization of at least 100,000 hectares as fishponds.

The prewar cost of constructing 1 hectare (2.47 acres) of bangos ponds ranged from 200 to 250 pesos in the provinces to 1,000 to 1,250 pesos near Manila. Costs are now four to five times higher all over the Philippines. The cost of fish has also increased proportionately.

PRODUCTION

The Philippine Bureau of Fisheries estimates that approximately 310 pounds of marketable-size bangos can be produced per acre of rearing pond (350 kilos per hectare). This figure is probably minimal, as good ponds are known to produce as many as 660 pounds per acre. These figures are based on only one crop per year.

At present, there are more than 61,000 hectares (150,000 acres) of bangos ponds in operation in the Philippines. The prewar assessed valuation of these 61,000 hectares of ponds was in excess of 30 million pesos. It is estimated that about 50,000 hectares of ponds are either under construction or under application at this time.

On the basis of only one crop per year, the annual production of bangos is in excess of 46 million pounds having a market value of approximately 20 million pesos. Additional revenue is derived from all bangos ponds because there are always other species of fish present, plus shrimps and crabs. Some revenue is also derived from the sale of nipa-palm-leaf shingles and mangrove firewood. Some pond owners also make solar salt in fishponds during the dry season.

PHILIPPINE FISHERY PROGRAM

Bangos culture is a big and important industry, and almost any type of research is bound to result in benefits to the industry. Since the beginning of the Philippine Fishery Program in the Islands, considerable thought and planning have been given the matter of improving current practices in the bangos industry. The first work here on bangos culture was started with the immediate purpose of determining possible methods that would increase production and provide more fish of this species for the food supply of the nation. As viewed now, there are two methods of achieving this end. One involves increasing the production per unit of area in the existing pondfish system. The other involves speeding up the growth of the fish so that more crops can be raised in a given period of time. The techniques it is hoped to apply are those common to good agricultural practice. Before such work can proceed, however, a rather careful analysis of existing conditions must be made. This involves, primarily, relating the accrual of fish flesh to the basic chemistry of water and soils in the fishponds and an evaluation of the intervening steps in the production cycle.

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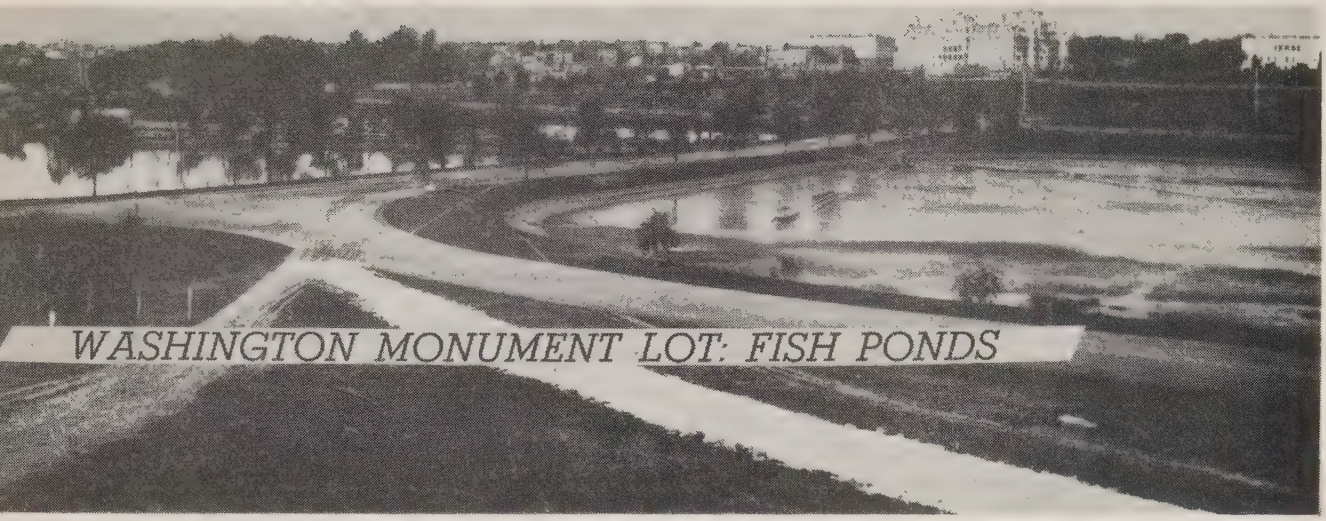
Most fish-culturists promptly start estimating losses in the crop when their charges are seen on their backs at the surface of the water--an indication of sickness or death. Breeders of catfish, therefore, would probably be disturbed by the unannounced appearance of Synodontis batensoda. This African catfish has the remarkable habit of swimming slowly or floating at the surface of the water with the belly upward.

The gar is one of the worst enemies of game fish in the South. The spread of hyacinth, which is destructive to game and pan fish, often favors the survival of the gar.

As a lake fills with hyacinth, the game and pan fish gather in remaining open water where there is sufficient dissolved oxygen. About these openings the gars destroy all game and pan fish except the small fingerlings that can hide in the hyacinth mats. As gars are able to breathe air, they are the last fish to be hurt by encroaching hyacinth.



About 1890, the White House and the State, War and Navy Building (now known as the State Building) in background.

In 1877, Congress authorized use of the Monument Lot for carp ponds. From two small lakes on the Lot, 6-acre ponds were built.

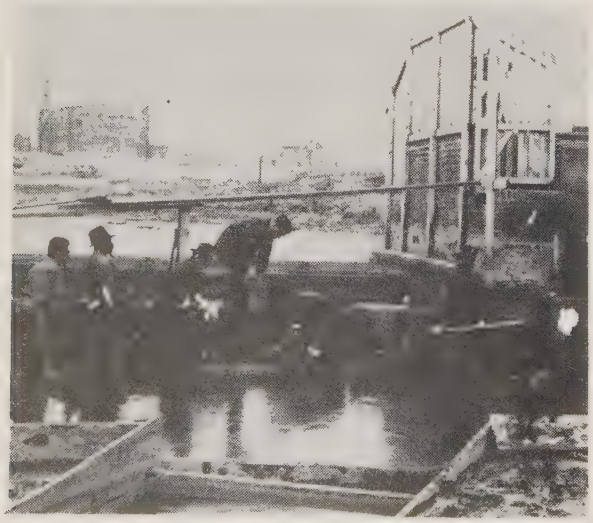
Two years later the pond west of Executive Avenue was halved by constructing causeways from the island to the east and west shores. This enabled contractors for the White House sewer to work without interference from the water.

The removal of the carp was always an occasion of much interest, and in April 1882 the President and many members of Congress watched the drawing of the ponds.

By the spring of 1887, it was necessary to fill in the east pond to strengthen the foundations of the Monument.

In 1896, the ponds west of 17th Street produced 300,000 carp, and other ponds produced largemouth, smallmouth, and rock bass, as well as shad. Less than 10 years later, however, it was decided that the "necessity for maintaining the extensive grounds in a manner befitting government property in the Mall considerably increases the operating expenses of the station without any benefits to the fish-cultural work"--and the ponds were filled.

About 1883, the old Bureau of Engraving and Printing in background, at 14th and B (now Independence Avenue).



INCREASING PRODUCTION OF BLUEGILL SUNFISH FOR FARM POND STOCKING

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INCREASING demands for bluegill sunfish to stock farm ponds in the vicinity of the U. S. Fish-Cultural Station (Leetown) near Kearneysville, West Virginia, focused attention upon the development of practices designed to produce many fish rapidly and experiments to determine the size most appropriate for stocking.

The experiments reported herein were conducted in 1947. They are part of a program directed toward increasing farm-pond and hatchery production.

The initial stocking of the farm pond is all important. A pond stocked with bass, 4 to 5 inches, and sunfish, 1 inch or less in length, will usually fail. The more nearly equal in size the sunfish and bass, the more likely it is that the initial stocking will be successful. Fortunately for the hatcheryman, the allowable size differential is quite large. Aside from their dubious chances for survival, bluegills an inch or less in length are difficult to handle and transport.

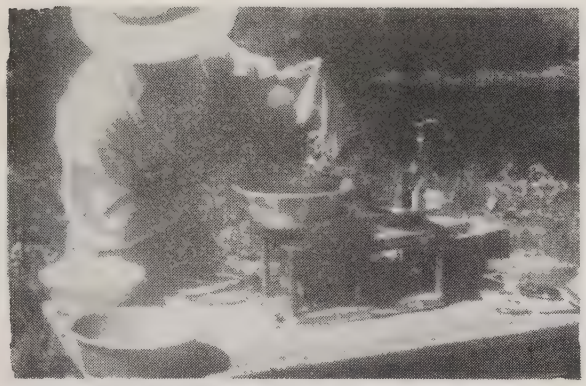
A series of 14 ponds, numbered H-1 to H-14, was selected for these experiments, and it was planned to raise two crops of bluegill sunfish annually in each. The early crop was initiated with bluegills held over winter from stock hatched late in the fall of 1946 and graded by passing through a wire-cloth grader of three meshes per inch. The second crop was obtained from the reproduction of adult bluegills placed in a spawning pond at the hatchery. The yield of this pond will be discussed later.

The early crop of bluegills was stocked in the 14 ponds (0.2 to 0.62 acre) on April 14, 1947, at the rate of 20,000 fish per acre. Two ponds were used as controls, and the remaining 12 ponds were fertilized with 10-5-5 inorganic fertilizer. Ammonium sulfate was used as a source of nitrogen, superphosphate as the source of phosphorous, and muriate of potash as a source of potassium.

The 14 ponds were arranged in four blocks, with one control each in the first and fourth blocks. One pond in each block received 100 pounds per acre, another received 200 pounds per acre, and a third received 300 pounds of the fertilizer per acre per application at 10-day intervals until June 12, a total of four or five applications per pond, depending upon the turbidity. Turbidity measurements were taken weekly during the operation of the ponds, as a second objective of the experiment was to produce water blooms of a density that would prevent the growth of the larger aquatic plants.

In spite of the heavy applications of fertilizer, water blooms appeared in only a few ponds. No relation was observed between the amount of fertilizer added and the production of algae characteristic of water bloom.

The early experiments were terminated during the period June 18 to July 3, 1947,



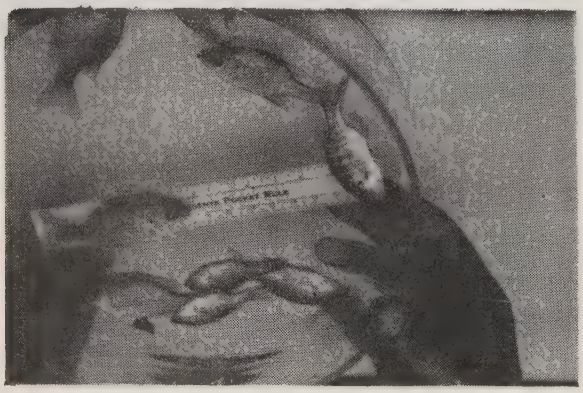


FIGURE 1.--The weight of this random sample of 1,000 young bluegills will be used in calculating the total weight of advanced fry or young bluegills required for stocking a nursery pond.

FIGURE 2.--Quieted first in a 3-percent salt solution, 100 bluegills are measured in a culture dish to determine the average size of the fish when removed from a pond.

FIGURE 3.--In inventorying a pond, all fish are first placed in liveboxes (60 by 26 by 26 inches), counted and weighed in samples of 1,000 to 2,000, and then released into a holding pond.

approximately 2-1/2 months after their inception. Results obtained are summarized in table 1. The sunfish in all ponds made excellent growth in the short period of operation. The average length ranged from 2.0 to 2.7 inches, so that these experiments provided fish of very desirable size for stocking farm ponds.

The control ponds averaged 86 pounds of bluegill sunfish per acre. The ponds that received a single application of 100 pounds of 10-5-5 fertilizer per acre produced an average of 133 pounds per acre. Those ponds that received 200 pounds per acre averaged 127 pounds of bluegill sunfish per acre (net). The smallest average production, 104 pounds per acre, occurred in the series that received 300 pounds of fertilizer per acre per application. In one pond (H-7) that received three times the normal application, bluegills were seen dying.

Immediately after the inventory of these ponds was completed, they were filled and restocked with bluegill sunfish fry of the year, during the period July 1 to July 14, 1947. The stocking rate, as well as the plan of fertilization, was the same as had been used in the first series of experiments. The number of bluegills was estimated by counting and weighing random samples (see figure 1) from a brood-stock pond. The fish being weighed, both into and out of the ponds, were drained in nets for a period of 45 seconds before weighing. Figure 2 illustrates the method of measuring bluegills, and figure 3 the counting operations.

As the method of production of the bluegill fry for the second series of experiments may be of interest, it is described briefly. A pond 0.48 acre in area was stocked on April 22, 1947, with 13 male and 26 female adult bluegill sunfish at the rate of 80 per acre. The 39 fish used weighed 16.75 pounds. Forty pounds of inorganic fertilizer were added to the pond on May 6. On May 14, 3.8 gallons of sodium arsenite were added to the pond to bring the coarse vegetation under control. The sodium-arsenite treatment destroyed the submerged aquatic plants; the good water bloom which followed persisted until fry-seining operations were over on July 14. During the period July 1 to July 14, 131,400 small

TABLE 1.--Production of bluegill sunfish in ponds at Leetown, West Virginia, 1947

Pond number	Date stocked	Date drained	Number days operated	Number per acre	Average length inches	Net pounds per acre	Net pounds per acre per day	Percentage survival	Fertilizer applications
A. No application									
H- 2	4/14/47	6/18/47	66	16,174	2.3	111.4	1.69	80.9	
H-13	4/14/47	7/ 2/47	80	13,258	2.0	61.3	0.77	66.3	
Average				14,716		86.4	1.23	73.6	
B. Single applications									
H- 4	4/14/47	6/19/47	67	13,919	2.5	121.9	1.82	69.6	4/30, 5/9, 5/20, 5/29, 6/12
H- 5	4/14/47	6/20/47	68	10,204	2.5	138.1	2.03	51.0	4/30, 5/9, 5/20, 5/29, 6/12
H- 9	4/14/47	6/27/47	75	15,360	2.4	132.0	1.76	76.8	4/30, 5/9, 5/20, 5/29, 6/12
H-12	4/14/47	7/ 2/47	80	21,826	2.4	138.5	1.73	109.1[1]	4/30, 5/9, 5/20, 5/29, 6/12
Average				15,327		132.6	1.84	76.6	
C. Double applications									
H- 1	4/14/47	6/18/47	66	5,625	2.4	63.0	0.95	28.1	4/30, 5/9, 5/20, 5/29, 6/12
H- 6	4/14/47	6/23/47	71	11,498	2.4	148.8	2.10	57.5	4/30, 5/9, 5/29, 6/12
H- 8	4/14/47	6/26/47	74	17,171	2.3	145.2	1.96	85.9	4/30, 5/9, 5/20, 5/29, 6/12
H-11	4/14/47	7/ 1/47	79	18,850	2.2	150.0	1.90	94.3	4/30, 5/9, 5/20, 5/29, 6/12
Average				13,286		126.7	1.73	66.5	
D. Triple applications									
H- 3	4/14/47	6/19/47	67	10,448	2.3	81.4	1.21	52.2	4/30, 5/9, 5/20, 5/29, 6/12
H- 7	4/14/47	6/25/47	73	2,040	2.7	19.5[2]	0.26	10.2	4/30, 5/9, 5/29, 6/12
H-10	4/14/47	6/30/47	78	17,240	2.2	132.4	1.70	86.2	4/30, 5/9, 5/20, 5/29
H-14	4/14/47	7/ 3/47	81	15,703	2.7	183.2	2.26	78.2	4/30, 5/9, 5/20, 5/29, 6/12
Average				11,358		104.1	1.36	56.8	

[1] The total number of fish stocked in each pond was estimated from weigning of random samples. The total number present at the time of drainage of the pond gives the actual number produced, as these were counted individually as well as weighed.

[2] Bluegill sunfish were found dying in considerable numbers in this pond on May 19, 1947.

TABLE 2.--Production of bluegill sunfish in ponds at Leetown, West Virginia, 1947

Pond number	Date stocked	Date drained	Number days operated	Number per acre	Average length inches	Net pounds per acre	Net pounds per acre per day	Percentage survival	Fertilizer applications	Chemical control (dates $CuSO_4$ was sprayed)
A. No application										
H- 2	7/ 3/47	11/10/47	129	12,149	2.3	81.7	0.63	60.7		
H-13	7/13/47	10/ 3/47	81	11,130	2.0	48.5	0.60	55.7		7/18, 7/31
Average				11,640		65.1	0.62	58.2		
B. Single applications										
H- 4	7/ 7/47	11/ 5/47	120	10,523	2.9	166.9	1.39	52.6	8/4, 9/2	7/24
H- 5	7/ 8/47	11/ 3/47	117	14,394	2.9	174.6	1.49	72.0	8/4, 9/2	7/24
H- 9	7/14/47	10/16/47	93	11,915	2.8	152.9	1.64	59.6	8/4, 9/2	7/18, 7/30, 8/27
H-12	7/ 9/47	10/13/47	95	14,990	2.3	109.5	1.15	75.0	8/4, 9/2	7/18, 7/31, 8/28
Average				12,956		151.0	1.42	64.8		
C. Double applications										
H- 1	7/ 1/47	11/12/47	133	9,100	3.2	182.5	1.41	45.5	8/4, 9/2	7/24, 7/31
H- 6	7/ 3/47	10/29/47	117	11,169	2.9	162.9	1.39	55.8	8/4, 9/2	7/24, 8/27
H- 8	7/ 8/47	10/21/47	104	11,305	3.2	258.4	2.48	56.5	8/4, 9/2	7/18, 7/24, 7/30, 8/27
H-11	7/ 9/47	10/14/47	96	11,671	3.3	277.1	2.89	58.4	8/4	7/18, 8/28
Average				10,811		220.2	2.04	54.1		
D. Triple applications										
H- 3	7/ 3/47	11/ 5/47	124	8,427	3.4	199.5	1.61	42.1	8/4	7/24
H- 7	7/ 8/47	10/21/47	104	10,274	2.9	145.5	1.40	51.4	8/4	7/18, 7/24, 7/28, 8/27
H-10	7/11/47	10/15/47	95	14,902	3.0	239.8	2.52	74.5	8/4	7/18, 7/30, 8/28
H-14	7/ 9/47	10/ 3/47	85	16,370	2.8	196.2	2.31	81.9	8/4, 9/2	7/18, 7/31
Average				12,493		195.3	1.96	62.5		

bluegill sunfish weighing 51.2 pounds were transferred from this pond to the 14 ponds in the experimental series.

It was planned to duplicate the fertilizer applications in the second set of experiments. Warm water conditions during late July and August, however, produced large mats of filamentous algae instead of water blooms. In most ponds, only two applications were made before the filamentous algae became abundant. Additional applications were suspended to avoid the characteristic and detrimental proliferations of these plants, which limit the space available for the production of fish. The large carry-over of fertilizing materials from the first experiments probably facilitated this great production of filamentous algae. In most of the ponds, efforts were made to control the pond-scum growths with copper sulfate, but these efforts had not much success. The copper-sulfate treatments were confined to the spraying of pond-scum masses only.

Table 2 shows the results of the second set of experiments. As in the first set, there was a decided advantage in single applications of the 10-5-5 fertilizer, but there was no advantage in supplying three times the amount of fertilizer normally added (100 pounds per acre). Most of the ponds were operated over a considerably longer period, but calculations of the results in terms of pounds per acre per day showed that the late summer experiments were comparable with the early experiments. In general, the bluegill sunfish produced averaged 2 inches or more in length. They are probably somewhat larger than necessary, and it is believed that satisfactory farm-pond stock may be produced by an initial stocking of 40,000 advanced fry per acre.

Practically all the bluegills that have been shipped from this station to fill farm-pond applications this year have been of such size that they were retained by a wire-cloth grader of two meshes to the inch (see figure 4). Data collected on the size and weight of bluegill sunfish which are retained or passed by graders of two and three meshes (to the inch) show the following: A two-mesh grader will retain fish 2.0 inches or more in length, although a few fish of that size have passed through. Three-mesh graders sort out bluegills about 1.4 inches and longer.

FIGURE 4.--Grader (two mesh to the inch) used in sorting bluegills for farm pond stocking.

Conclusions

1. The method of rearing bluegill fry in nursery ponds, as described, appears efficient in the production of stock for farm ponds.

2. There was little or no advantage in adding more than 100 pounds of 10-5-5 inorganic fertilizer per acre to nursery ponds.

3. The addition of large quantities of inorganic fertilizer did not encourage water blooms in the Leetown ponds.

4. A stocking rate of 20,000 advanced fry per acre of nursery pond is probably lower than necessary to produce bluegills of suitable size for farm-pond stocking. Thirty or forty thousand advanced fry per acre of nursery pond might provide more fish of desirable size.

5. The fish from nursery ponds stocked at 20,000 per acre averaged 2.0 to 3.4 inches in length and required no grading before being planted with bass of the size ordinarily distributed in the fall.

NEW SUBSTANCES OF POSSIBLE VALUE IN FISH DISEASE CONTROL

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The microbiological slime problems of the pulp and paper industry have created a demand for substances to abate these nuisances. Because these compounds are finally discharged into waterways as part of the mills' effluent, the paper industry, as well as some chemical firms, has studied the potentialities of these toxicants as stream-polluting agents. As a partial result, the toxicity thresholds for fish of several slime-control agents have been established by Goodnight (1942) and by Van Horn (1943). During this investigation, one of these agents, pyridylmercuric acetate (Pyridose) was found by Van Horn and Katz (1946) to control fish diseases. Since then, Rucker (1948) has found pyridylmercuric acetate to be effective in the control of bacterial gill disease.

The author would, therefore, like to suggest several other compounds, used in the paper industry, which seemed to have some prophylactic value to the cyprinid, Notropis atherinoides, the lake emerald shiner. It must be emphasized, however, that these substances were tested with the original intent of determining their stream-pollution potentialities, and observations as to their disease-control values were incidental and fragmentary. It is felt, nevertheless, that further experimentation may show one or more of these bactericides to be of value in hatchery work.

Mr. Katz is U. S. Public Health Fellow at the School of Fisheries, University of Washington.-- The EDITORS.

These substances are of three major types: organic mercurials, chlorinated phenols, and organic detergents. The organic detergents, such as Roccal, have already found their place in fish-cultural work (Fish, 1947); so the remarks of the present author will be confined to the first two classes of compounds. These substances are very toxic to fish: the minimum lethal threshold of some of these was less than 1 p.p.m.

The minimum lethal concentration of some slime-control agents to the lake emerald shiner may be listed (Van Horn, 1943; Van Horn and Katz, 1946) as follows:

Agent	Minimum lethal concentration in p.p.m.
Santobrite	0.2
Merfenel	0.02
Lignasan	0.8
Nalco 23	1.4
Nalco 21	0.4
Pyridose	0.15

These values were determined by keeping the fish for 5 days in solutions of various concentrations of the toxicant. It is felt that much higher concentrations can be used effectively and safely as dips, but that is a matter for further research.

It is of interest that these agents differ in their toxicity to bacteria with changes of pH. Appling, McCoy, and Shema (1947), determined that Lignasan was most

toxic to Aerobacter aerogenes, Bacillus mycoides, and Aspergillus niger at pH 7. Merfenel is most toxic to Aerobacter aerogenes at pH 7, and to Bacillus mycoides and Aspergillus niger at pH 8.5. Dowicide G, a chlorinated phenol, is most toxic to Aerobacter aerogenes at pH 4, to Aspergillus niger at pH 5, and to Bacillus mycoides between pH 6 and 7. It is realized that no hatchery waters approach the pH of maximum toxicity of some of these substances, and it is further realized that the enumerated slime-forming bacteria are not the cause of any known fish diseases. Many of these agents will be most toxic to fish parasites at pH's different from those named, but it is felt that these data do indicate that certain agents may be more effective in hatcheries with alkaline waters and others may be more adaptable to hatcheries with acid waters.

Admittedly, the above information is very fragmentary and much research will be necessary before any of these substances may take a place in fish-cultural practices. It may be too much to hope that substances which kill slime bacteria will control fish diseases in a hatchery installation, yet it would be shortsighted to overlook materials--now being produced cheaply for use in industry--that might solve a perplexing and costly disease-control problem.

Appling, J. W.; McCoy, J. F.; and Shema, B. F.
1947. Studies in slime control--1946. Paper Trade Jour. 124 (22): 143-154.

Fish, F. F.
1947. Disease control in hatchery fish. U. S. Department of the Interior, Fish and Wildlife Service, F. L. 222.

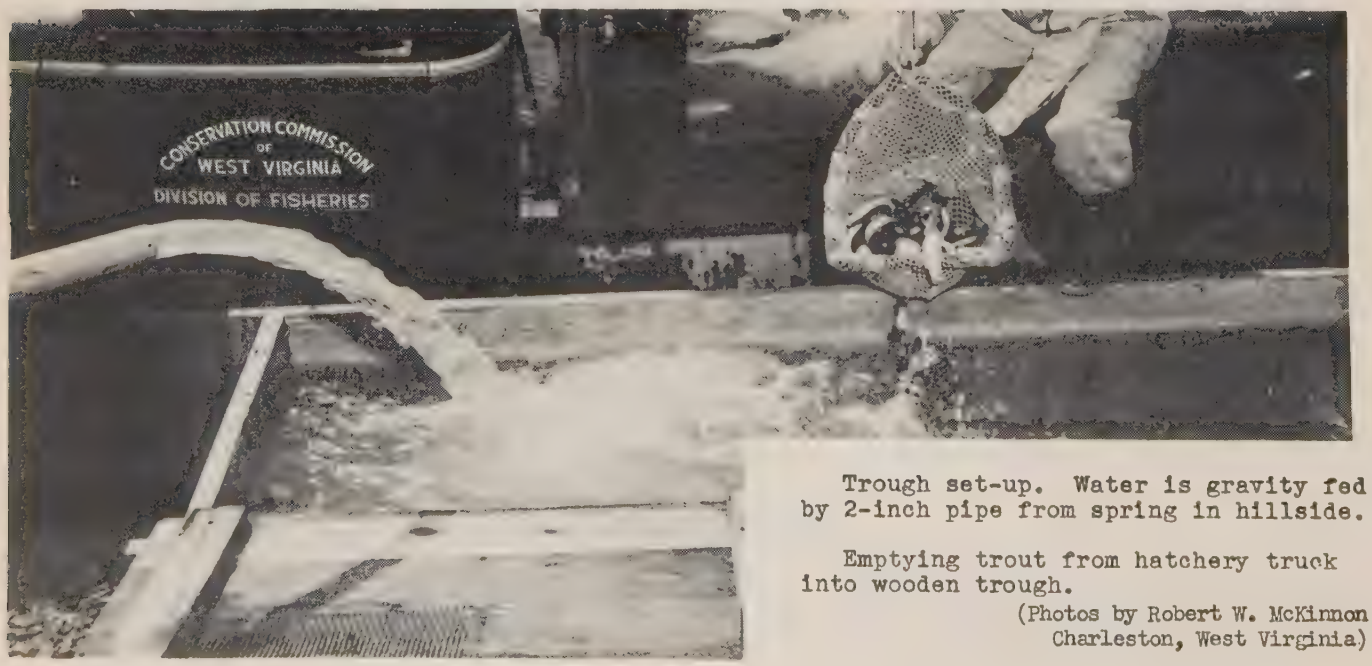
Goodnight, C. J.
1942. Toxicity of sodium pentachlorophebate and pentachlorphenol to fish. Ind. and Eng. Chem. 34 (7): 868-872.

Rucker, R. R.
1948. New compounds for the control of bacterial gill disease. Prog. Fish. Cult. 10 (1): 19-22.

Van Horn, W. M.
1943. Possible stream pollutional aspects of mill antiseptics. Paper Trade Jour. 111 (23): 33-35.

Van Horn, W. M., and Katz, M.
1946. Pyridylmercuric acetate as a prophylactic in fisheries management. Sci. 104 (2710):557.

Water less than 18 inches in depth has little value in the farm fish pond. By eliminating shallows it is possible to reduce the mosquito problem, increase the forage area for the fish, and control more easily aquatic vegetation.



Trough set-up. Water is gravity fed by 2-inch pipe from spring in hillside.

Emptying trout from hatchery truck into wooden trough.

(Photos by Robert W. McKinnon
Charleston, West Virginia)

NEW SYSTEM OF TROUT DISTRIBUTION IN WEST VIRGINIA

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Charleston, West Virginia

Many trout streams in West Virginia are not accessible to the commonly used large distribution truck of the hatchery. This being true, coupled with the usual "rush" that occurs in spring stocking season, many times large numbers of fish have been literally dumped into streams at the more accessible places, notably at highway bridges.

This year a new system was inaugurated. A cooperative project with the Monongahela National Forest proved much more efficient in trout stocking.

The major concerns were (1) better distribution of legal-sized fish throughout the stream, and (2) availability of the personnel and equipment to do the job.

Game and fish biologists of the Conservation Commission decided that substations where wooden holding troughs could be located would suit the needs of slowing down the "rush." The troughs were to provide a means of transferring the trout from the large hatchery trucks to field vehicles which could do the job of transporting the fish across bad roads, fire trails, and so forth.

The accompanying photographs show the holding troughs which were used. These were 6 feet long, 3 feet wide, and 2 feet deep. Pairs of the troughs were placed in five locations in and around the National Forest. Fish were hauled from the hatchery to the troughs. There, as many as 1,000 trout were placed in each trough. After the trout were settled and "refreshed" in the clean spring water (as in the trough set-up in the photographs), they were placed in smaller wooden troughs on pick-up trucks or a Dodge power-wagon truck and then hauled short distances to streams in the vicinity of the trough location.

Loading Dodge power wagon, equipped with a small trough, for hauling fish to streams.

Helping in the actual field distribution of trout were field fishery biologists, game technicians, law-enforcement officers, National Forest district personnel, and sportsmen.

This system has several advantages which we feel are worth noting. First, it allowed better distribution of fish in the stream, precluding the former inefficient practice of dumping hundreds of fish in one or a few accessible pools. Second, the hatchery personnel had no

worry about stocking the trout: the hatcherymen had merely to haul the fish to the troughs. This permitted more time at the hatchery for preparatory grading and general care of fish prior to stocking trips. Third, sportsmen actually saw that the fish were stocked, and these men appeared to enjoy taking part in the work. Fourth, the trout were released in riffles instead of pools. It is felt that this affords better distribution of the fish, so that there will be less congregating of great numbers in pools. Fifth, the speed at which the fish could be stocked was amazing. As many technicians and sportsmen were on hand, plus the proper equipment for hauling, the fish were released many times faster than in previous years. In one instance, 9,000 trout were well stocked in a 2-day period. The same area often took more than twice that time when stocked directly from the hatchery truck.

Trout were often held in the troughs overnight and in one location were retained several days. Each trough was provided with a wodden lid which could be locked to discourage night poachers. The overflow drain of the troughs was in the form of a screened slit at one end. This was located low enough to permit adequate space above the water level for jumping of the fish when the lid was closed.

The Albatross III, commissioned by the Fish and Wildlife Service as a fishery-research vessel, already engaged in an intensive study of New England fishing banks.

IMPROVED REARING POND

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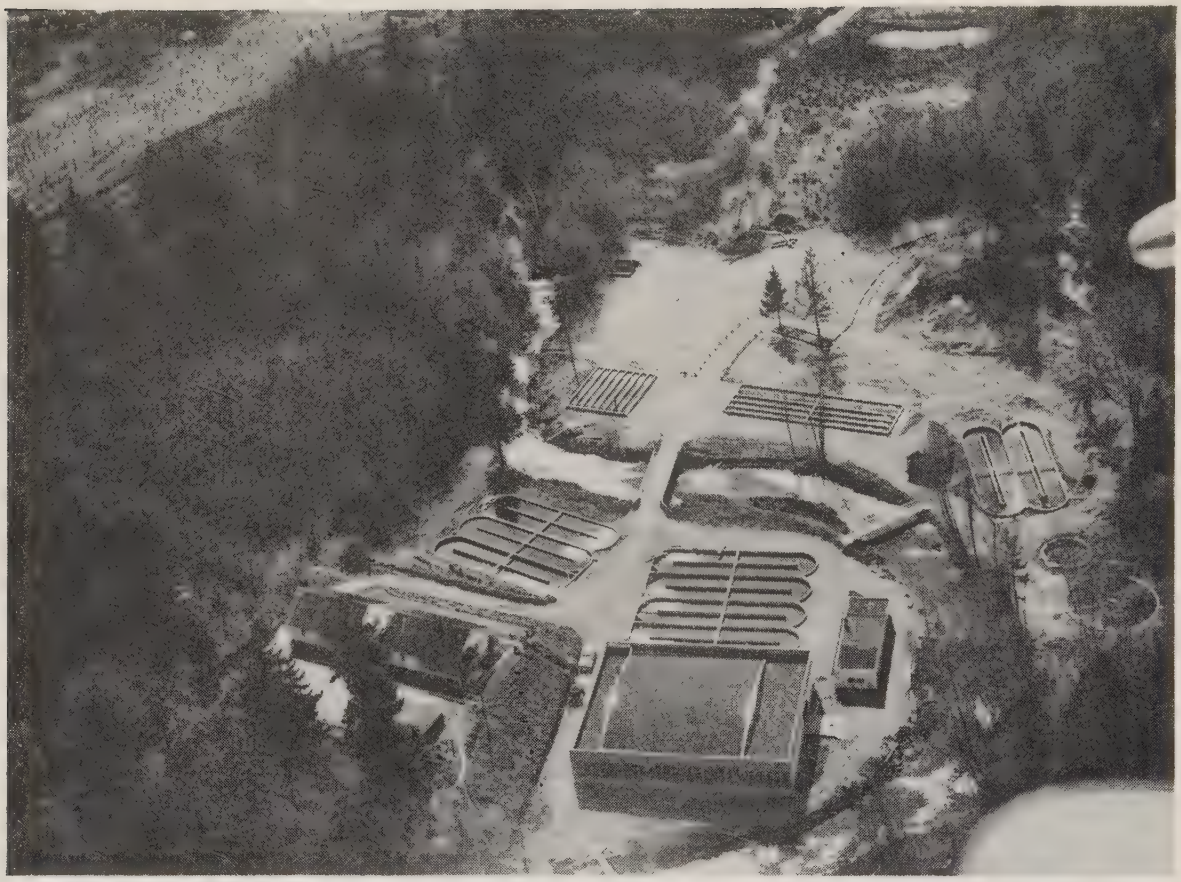
Among hatcherymen there is, perhaps, no general agreement on the specific features which constitute an ideal rearing pond for trout and salmon. This is true principally because the conditions at each hatchery vary and because different species and sizes of Salmonidae often require a particular set of conditions or a special method of handling in the process of successful rearing. Then, too, a difference in personal opinion enters the picture in a small degree, and undoubtedly there will always be a controversy between the advocates of concrete ponds and natural ponds, and between those who favor circulating-type ponds rather than raceways.

In any hatchery construction or improvement program, however, there are the following important objectives which the pond designer must keep foremost in his thoughts: 1. To provide for a compact rearing-pond layout commensurate with the ultimate development of the station. 2. To provide at the intake and outlet water-conducting facilities which will not only meet the normal operating demand but will, in addition, meet the special requirements of pond cleaning, treatment of fish, or the collection and handling of fish. 3. To provide sufficient slope on pond bottom for complete drainage, and to incorporate a type of bottom surfacing which will not shift, entrap, nor injure fish, and which will not be unduly slippery under normal conditions. 4. To design the rearing pond in such a manner that the movement of water will provide for both adequate current and resting areas. 5. To provide for a practicable means of collecting pondfish for removal, sorting, or treating. 6. To provide an adequate pond-screening area with types of pond outlet and intake regulators which are positive in action and placed in such a manner that they will be reasonably free from frost, damage by rolling equipment, or movement by visitors. 7. To incorporate the above-mentioned features in a rearing pond as economically as possible and with due consideration for operational and maintenance costs.

The Washington State Department of Fisheries has used for many years a standard circulating-type rearing pond, 20 feet wide and 80 feet long, with 10-foot-radius ends and a full-height center wall. All walls are of 6-inch concrete, and practically all ponds have gravel bottoms sloped 6 inches in the 160 feet from inlet to outlet, both of which are on the same end of the pond. Screening area is provided diagonally across the only square corner of the pond. The water inlets are of 3-inch pipe; the valves are above ground and the pipes extend 4 feet into the pond through a port in the curved end wall. A 1-foot-square shallow sump, into which a wooden box (18 inches high) is fitted, forms the water-holding and pond drain control. A 6-inch stovepipe elbow cast in the sump of the concrete floor section behind the screen provides the outlet to the battery drainage system.

These ponds were economical to construct, and they have served their purpose adequately. However, there were several features which made the processes of cleaning, collection of fish, and maintenance much more cumbersome and time-consuming than need be. Thus, in 1944, when a general hatchery-expansion program got under way, the Minter Creek Experimental Hatchery was designated as the proving ground for the construction and operation of different types of rearing ponds. (See photograph.)



Minter Creek Experimental Hatchery. (Photo courtesy of author)

The water supply at the Minter Creek Hatchery was such that the rearing capacity of the station could be doubled. A new pipeline was installed, and 17 new ponds were constructed. These ponds included a battery of eight 4- by 40-foot concrete raceways with a kettle (4 feet by 4 feet by 7 inches) at the lower end of each raceway; a battery of five 5- by 90-foot concrete raceways with kettles; three standard-size circulating-type concrete ponds and a 50-foot circular concrete pond. Each of the ponds had an individual water supply line and an adjustable standpipe drain.

After a year of experimentation under varied conditions, the hatcherymen selected one of the three improved standard ponds as being the best suited for salmon rearing. This particular pond was designated the Thayer-Ellis pond and with minor modification was adopted as a standard for future construction in the Washington Department of Fisheries. (See sketch.)

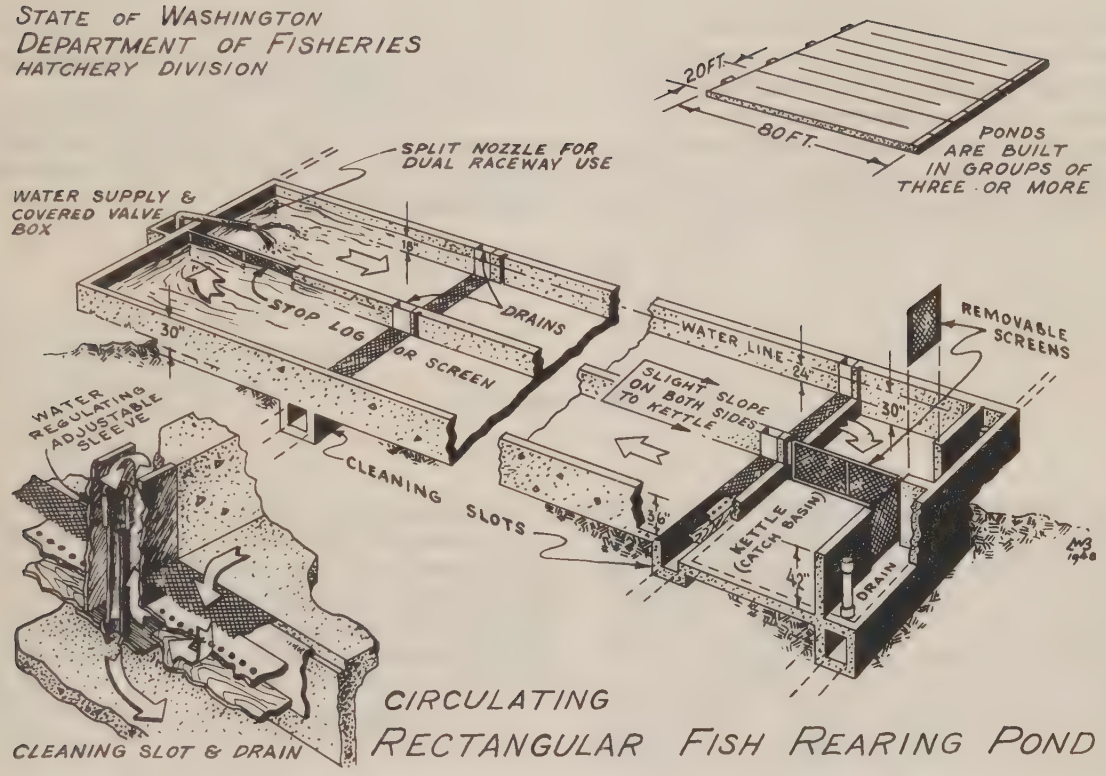
Advantages of the improved pond over the old standard pond may be enumerated as follows:

1. The new pond may be operated as twin raceways by inserting stop-log panels between the ends of the center wall and the ends of the pond, and by removing the pipe cap from one branch of the dual inlet.

2. A 6-inch slope on the concrete bottom from the head of the pond to the kettle step, a distance of 70 feet, provides positive drainage.

3. A kettle, 10 feet by 20 feet by 7 inches, provides adequate holding space for fish during the fish collecting, sorting or treating, and pond-cleaning operations.

4. Screened cleaning slots are provided in the concrete floor of the pond near the inlet end and immediately in front of the kettle step. The desirability of the floor slot near the inlet end is dependent upon the amount of bed



load material in the pond water supply. The floor slot near the kettle is primarily for the purpose of eliminating accumulated waste, algae, and other material deposited on the sides and bottom of the pond without such materials having to pass through a concentration of fish. Such deposits can be drained off readily in the cleaning operation after fish have been drawn into the kettle, while the water supply for fish in the kettle is maintained by a siphon tube from behind the screen of an adjacent pond.

5. Pond screens at the outlet have an area of approximately 30 square feet, and the bottom of the screen frame is set behind a ledge in the floor so that complete drainage of the kettle section is possible without removal of the screens.

6. Pond drains are designed so that the rate of drain can be regulated and so that water can be drawn off the bottom of the pond as well as from the surface. Also, the standpipes are so constructed that a pond can be drained safely down to the kettle level while the operator is performing other work.

In field tests of the efficiency of the new ponds it was found that the cleaning operation alone saved more than 1 man-hour per pond as compared with the former standard ponds; thus, at a 20-pond hatchery more than 1,000 man-hours per year could be saved. In addition, the features of the new pond allow for greater accuracy and speed in sampling, sorting, and removing fish.

The new pond design eliminates the curved ends of the old standard pond, thus greatly reducing the cost of construction. Usually, the ponds are placed in batteries of five or six, the drain and supply lines running the full length of the battery. The pond floor troughs are fitted with screens, and a stationary

panel of aluminum or wood with drilled holes acts as an orifice board and distributes the pull of water across the entire width of the pond battery. A false bottom in the floor trough provides a lower tunnel into which waste water and debris are passed through a standpipe opening. The standpipe proper is 4 inches in diameter and is set into a cut-out section of each 6-inch concrete wall.

Normally, these standard-size ponds are supplied with 150 gallons of water per minute and are stocked with 150,000 No. 1 fingerlings for the first few months of rearing. In successive stages the pond populations are reduced to approximately 25,000 fish to be retained for rearing to yearling size.

On the basis of 1947 construction costs, it is estimated that the new ponds to be built in 1948 will cost between $1,800 and $2,400.

DESIGNING FARM PONDS

The secret of successful farm pond designing is to provide for adequate water to fill the pond and guard against excessive silting, according to L. L. Harold, SCS research, Coshocton, Ohio. To provide for adequate water supply, allow sufficient drainage area to furnish ample quantities of runoff water in the pond during critical drought periods. Excessive silting can be avoided by keeping the drainage area down to the absolute requirements of the storage capacity of the pond and by keeping at least 50 percent of the drainage area in permanent vegetal cover, such as grass or woods.

--Soil Conservation 13 (12): 271

Three of the five experimental farm ponds at the U. S. Fish-Cultural (Leetown) Station, near Kearneysville, West Virginia, were opened for fishing on June 22, 1948. A year old, the bass had attained a length of at least 9 inches and the bluegill sunfish a length of 5 inches.

In three of these ponds, sunfish and bass will be removed in the ratio of 10 to 1 and, if possible, at the rate of 30 pounds of fish per acre per month for 5 months. The fish in the other two ponds will be removed without a system.

COMMENTS

Provincial Administration of
The Cape of Good Hope

Inland Fisheries Department
P. O. Box 152
Stellenbosch

27th April 1948

The Editor,
PROGRESSIVE FISH-CULTURIST,
Fish and Wildlife Service,
Merchandise Mart,
Chicago 54,
Illinois. U. S. A.

Sir,

I have read the article "Foreign Introductions of North American Fishes" by Myers (1947) with very great interest. There is a great diversity of opinion on this subject in South Africa, where each of the four Provinces controls its own inland fisheries.

Owing to the dearth of indigenous, edible, and sporting fish in the waters of the Cape Province, fisheries development has been based almost entirely on the introduction and acclimatization of exotic species. The first step in this direction was the introduction of Brown and Rainbow Trout in 1890. These were successfully acclimatized and are regarded today as our premier sporting and table fish. A less fortunate measure, and one for which we are paying dearly today, was the introduction of Carp in 1896. These have proved to be voracious and omnivorous and so compete for the food supply of more desirable fish. Furthermore, no spawning ground is safe from their attacks. Carp have gained access to some of our best trout streams and are to be found in most lakes and reservoirs. In such waters all vegetation has been destroyed and the water discoloured by the "grubbing" action of the Carp. While they grow rapidly and may attain a weight of over 40 pounds, they are poor sporting and edible fish.

As it was found that trout were suited to very few localities in this Province, a number of North American pond and river fishes were introduced. These included Largemouth Bass (Huro salmoides), Smallmouth Bass (Micropterus dolomieu), Spotted Bass (Micropterus punctulatus), and Bluegill Sunfish (Lepomis macrochirus). The Largemouth Bass have been established in numerous reservoirs and farm dams, and have proved a good sporting and table fish. Smallmouth Bass are thriving in many rivers which are too warm for trout. They are considered superior to the Largemouth in sporting qualities and at least equal as a table fish. The Spotted Bass is a recent importation, and little information on their suitability to the waters of this Province is available yet. From the fish-culturist point of view, however, they are easier to culture than either of the above-mentioned species.

The Bluegill Sunfish is well established in our waters. They are a superior pondfish and provide good sport on light tackle. They are extremely prolific, however, and unless strictly controlled, tend to overpopulation. Large populations of stunted Bluegills have in many cases accounted for the disappearance of Largemouth Bass. I do not think, however, that this can reasonably be used as a case against the importation of exotic species. It is merely proof that the waters are not correctly managed. The majority of angling societies and farmers take great pains to stock their waters. Once the fish are established, however, no effort is made to maintain those waters. For fish farming in this Province the Bluegill Sunfish - Bass combination remains the most suitable.

I am in entire agreement with Myers (1947) that when stocking a water, indigenous fish should be given priority. With the exception of the Yellowfish of the Olifants River, however, we have no indigenous fish to equal the imported varieties already described. The Tilapia family, which occurs farther north, includes at least five species of carnivorous and five vegetable feeders which must be ranked high as both table and

sporting fish. All attempts to acclimatize them in our waters have failed, owing to the severe winter conditions.

The term exotic is relative and one which has given rise to a great deal of unfortunate controversy. There are those who would use only South African fish for South African waters, the main criterion of quality or suitability being whether a fish is native or not. The policy of this Department is to place the most suitable fish in a river irrespective of whether it is exotic or indigenous. A fish species from central Africa would be just as "exotic" in our waters as one from North America. In fact, a fish from an adjoining river system which might be only a few miles distant cannot be regarded as truly indigenous to waters where it does not occur naturally.

Had it not been for the importation of exotic fish from North America and Europe, there could have been no Inland Fisheries in this Province. Admittedly, mistakes have been made, but we are gaining in experience. While any proposals for new importations would be very carefully investigated, we do not propose to close our doors to all prospective fish immigrants.

/s/ D. Hey
Director of Inland Fisheries.

"El Zarco" Trout Hatchery, Salazar, Mexico. View shows entrance to grounds, formal gardens, illuminated fountain and cascades, and hatchery building in background.

FROM PUBLICATIONS

REPRINT

TWO YEARS OF FISHING IN LAKES WITH LIBERALIZED REGULATIONS

H. E. Predmore, Jr.
Institute for Fisheries Research

After two years of intensive creel census on 12 experimental regulation lakes, the evidence obtained to date shows no general decline in fishing quality although year-around fishing is permitted for certain species. Most of the extra open season allowed by the special regulations falls during the spring when other southern lakes are closed to fishing. As a result, a 16 per cent increase in fishing has occurred. Because of their "experimental" classification, many anglers who would normally fish in other lakes have been attracted to these waters. In 1947, thirty-seven per cent more anglers fished the test lakes than in 1946. Summer fishing in 1947 showed no over-all decline in angling quality. Out of the 12 lakes fishing improved in six, remained the same in five, and became somewhat poorer in one as compared to 1946.

For the anglers who are unfamiliar with the experimental lakes program, the reasons for proposing liberalized fishing laws[1] are: (1) Experimental evidence shows that in most lakes only a small proportion of the available legal game fish are ever harvested by hook and line angling. (2)

As stated on the poster, Whitmore Lake, popular and heavily fished, is open to year-around angling for species not protected by closed seasons. Crappies, rock bass, perch, bullheads, etc., may be taken here at any time as on non-trout streams and non-trout lakes north of Highway M-46.

Many lakes contain large numbers of stunted (abnormally slow-growing) under-sized fish which seldom attain legal length in their life span. Such lakes contain too many small breeders with the result that the available food supply is inadequate for normal growth. (3) Intensive unrestricted fishing on experimental lakes in other states has demonstrated that anglers were able to remove only half the catchable fish leaving ample numbers

1/ See Michigan Conservation, 1945, Vol. XIV, No. 9, pp. 6-9; No. 10, pp. 6-9; 1946, Vol. XV, No. 5, pp. 5, 13-14.

Reprinted, with illustration, from Michigan Conservation 17 (6): 3, 12. June 1948.

of breeder fish.

In view of these facts the Legislature, in 1945, granted the Conservation Commission authority to designate a maximum of 20 lakes and 10 streams (but no more than one lake and one stream per county) as experimental waters to test the effect of liberalizing the fish laws.

The following is a summary of part of the information obtained in a creel census of 12 experimental lakes. The census involved an enumeration of the fishermen on about 30 per cent of all days during which the results from 10 to 90 per cent of all fishing trips were recorded in a system of stratified random sampling. The table accompanying this article summarizes the data for the individual lakes according to three periods: spring, summer, and fall. The spring period includes all data collected March through June 24. The summer period extends from June 25 through September 15, and the fall records from September 16 to about the first week in November.

On Lobdell, Pontiac, Whitmore, Craig, Duck and Fine Lakes, regulations have been slightly relaxed to permit year-around fishing for perch, crappies, rock bass, and non-game fish. A short closed season, March 15 to May 15, is in effect on northern pike and walleyed pike. Bass fishing is illegal from January 1 through June 24. The closed season on bluegills and sunfish extends from February 28 through June 24. Regulations on these lakes are exactly the same as those which have prevailed on most non-trout lakes north of Highway M-46 since 1946.

In 1946, the combined estimated total anglers who fished the above six lakes during the spring period numbered 9,200. They harvested 14,630 fish. The following spring 8,950 individuals caught 11,263 fish. In the summer of 1946 these lakes accommodated 69,400 sportsmen who caught 224,500 fish. The number of anglers increased to 100,000 in the summer of 1947, and 403,900 fish wound up on the anglers' stringers. A total of 7,160 anglers fished in the fall of 1946. They took home 18,900 fish. In the fall of the following year 13,850 fishermen tried their luck and caught 39,000 fish.

Fishing quality based on catch per hour varied considerably among the six lakes for the three seasons during 1946 and 1947. The changes from 1946 to 1947 were as follows: In the spring period fishing success declined in Craig, Fine and Pontiac Lakes. Angling was about the same on Lobdell and Whitmore Lakes. Duck Lake showed an improvement. Angling was much better in the summer period. In this season the catch per hour increased on Craig, Pontiac and Whitmore Lakes. Fishing was about the same as in 1946 on Duck, Fine, and Lobdell Lakes. No decrease in catch per hour from 1946 occurred during the summer. The fall fishing showed a decline in catch per hour on Duck and Pontiac Lakes in 1947. It remained the same for Whitmore Lake and improved on Craig, Fine and Lobdell Lakes.

Combined figures show that 208,560 anglers fished in the two years and 712,193 fish were caught during the ice-free seasons from these six lakes.

There are no size or season restrictions on bluegills, sunfish, perch, rock bass, and crappies at Bear and Saddle Lakes, but creel limits are in force on these species of six inches or longer. Regulations remain unchanged for species other than those mentioned above.

Results on Bear Lake for combined spring, summer and fall angling were as follows: A total of 3,350 anglers caught 8,090 legal and 3,040 under-sized fish in 1946; and the next year 4,280 fishermen caught 7,400 legal and 3,220 under-sized fish. About one-fourth of the total fishing trips were made in the spring period. Approximately 12 per cent of all legal fish caught in both years were taken prior to June 25. As compared with 1946, the catch per hour declined in the spring period, but was improved during the summer and fall seasons.

Reports on Other Lakes

In 1946, Saddle Lake was fished by 6,920 anglers. In return for their efforts they caught 28,300 legal-sized and 27,600 under-sized pan fish. In the succeeding year fishing pressure increased to 13,600 anglers who took out of the lake 41,400 legal pan fish plus 52,360 undersized. More than a third of both years' fishing occurred prior to June 25.

TWO YEARS OF CREEL CENSUS RESULTS ON TWELVE EXPERIMENTAL LAKES

Lake	Period	Total anglers		Total legal-size fish caught		Total under-size fish caught		Catch per hour	
		1946	1947	1946	1947	1946	1947	1946	1947
Craig (Branch county)	Spring	400	500	240	23	-	-	0.1	0.02
	Summer	4,700	3,400	10,200	9,400	-	-	0.7	0.9
	Fall	470	850	1,100	4,000	-	-	0.8	1.4
Duck (Calhoun county)	Spring	1,900	900	4,100	3,300	-	-	0.7	1.3
	Summer	12,900	17,800	34,300	50,600	-	-	1.0	1.0
	Fall	2,900	2,400	7,400	3,700	-	-	1.0	0.6
Fine (Barry county)	Spring	1,400	450	2,200	500	-	-	0.7	0.4
	Summer	12,100	11,800	61,000	46,900	-	-	1.8	1.7
	Fall	1,200	1,400	3,800	4,900	-	-	1.2	1.4
Lobdell (Genesee county)	Spring	1,900	1,800	3,200	3,900	-	-	0.6	0.7
	Summer	11,100	19,100	36,600	67,300	-	-	0.8	0.9
	Fall	610	2,700	1,200	10,800	-	-	0.7	1.4
Pontiac (Oakland county)	Spring	2,400	3,600	4,200	2,800	-	-	0.4	0.2
	Summer	14,100	32,700	47,900	185,000	-	-	0.7	1.4
	Fall	980	4,200	3,200	11,200	-	-	0.8	0.6
Whitmore (Livingston county)	Spring	1,200	1,700	690	740	-	-	0.2	0.2
	Summer	14,500	15,200	34,500	44,700	-	-	0.7	1.0
	Fall	1,000	2,300	2,200	4,400	-	-	0.6	0.6
Bear (Hillsdale county)	Spring	630	1,100	1,300	500	1,040	520	0.8	0.4
	Summer	2,400	2,600	5,900	5,700	1,900	2,500	0.9	1.1
	Fall	320	580	890	1,200	100	200	0.6	0.8
Saddle (Van Buren county)	Spring	3,000	4,400	14,100	18,900	17,900	31,360	2.5	3.0
	Summer	3,500	8,100	12,800	21,900	8,700	19,500	2.0	1.9
	Fall	420	1,100	1,400	600	1,000	1,500	2.1	0.9
Big Portage (Jackson county)	Spring	1,200	1,500	1,900	1,600	-	-	0.4	0.3
	Summer	1,500	2,900	2,500	5,600	-	-	0.6	0.7
	Fall	220	580	420	1,500	-	-	0.6	0.9
Fife (Gr. Traverse county)	Spring	1,500	900	1,800	2,200	-	-	0.4	0.7
	Summer	9,200	8,400	15,900	20,900	-	-	0.5	0.8
	Fall	360	1,200	820	2,700	-	-	0.7	0.9
Minnewaukon (St. Joseph county)	Spring	1,500	1,900	8,200	8,200	-	-	1.9	1.6
	Summer	2,300	3,000	11,100	9,700	-	-	1.8	1.3
	Fall	270	680	1,100	1,900	-	-	1.5	1.1
Sugarloaf (Washtenaw county)	Spring	2,600	1,100	6,600	2,800	-	-	0.7	0.8
	Summer	2,300	2,100	4,500	6,400	-	-	0.7	1.0
	Fall	340	420	1,300	1,300	-	-	1.4	1.8
Total	-	119,320	163,360	350,560	567,763	30,640	55,580	-	-

Of the total legal-sized fish caught (69,700) in the two years, nearly half were taken before June 25. The catch per hour figures indicate that in 1947, as compared with 1946, spring fishing improved, summer fishing remained the same, and fall angling suffered a slight decrease in catch per hour.

Big Portage, Fife, Minnewaukon, and Sugarloaf Lakes are open to fishing for bluegills and sunfish at all times. Ordinary closed seasons are in force for other species.

Results from the 1946 creel census of these lakes show that 23,290 anglers took 56,140 fish during the ice-free seasons. In 1947, fishing pressure changed very little on these lakes and 24,680 anglers were rewarded with an increased catch of 64,800 fish. About one-fourth

of all fishing was done in the spring period and slightly more than one-quarter of all the fish creeled were taken prior to June 25.

Additional Sport Provided

Comparing 1947 with 1946 spring period angling on these four lakes, the catch per hour dropped on one, remained even on two, and rose on one. Fishing quality in the summer period improved on two lakes, remained the same and declined for each of the two remaining. Fall fishing declined on one lake and improved on the other three.

The extra fishing allowed by the liberalized regulations on these 12 lakes made it possible for 39,480 anglers to take 93,993 legal-sized and 50,820 undersized fish. In addition 35,400 undersized fish were taken during the ordinary fishing season. It is too early to reach any definite conclusions as to the effects of more liberal fishing regulations, but the evidence to date suggests that removing some of the present restrictions at least on pan fish has not had any harmful effects on the summer fishing and has provided some additional sport at a time of year when there is little other angling available.

W O R M Y O R G R U B B Y F I S H

G. W. Buller
Chief, Division of Fish

This is the time of the year when the Commission of Game and Inland Fisheries receives many inquiries about the appearance of wormy or grubby fish in our fresh water streams. This condition is the result of an infestation by trematode worms of the genus Clinostomum. The young immature worms encyst in the muscles or beneath the skin of fishes and frogs and often cause wart-like bumps or protuberances.

There is absolutely no danger of the worms infesting human beings, even if some should be eaten. However, when fish contain large numbers of these parasites there is naturally a strong prejudice against eating them.

The study of the life cycle of the parasite shows that it is dependent upon fish-eating birds and snails for completion. When a fish-eating bird, such as a heron or bittern, eats a wormy fish the young worms grow to maturity and remain attached to the throat or mouth of the bird. Each worm lays countless numbers of eggs which pass through the bird and are often deposited in water. Here the eggs hatch and the minute worms penetrate, if present, some species of snail. In this host the parasites undergo further changes and emerge from the snail in a form that can penetrate fish. If a suitable fish or frog host is encountered, such as a perch, bass or sunfish, the parasite enters, encysts and causes the grubby condition. The infestation occurs during the summer but by late fall, all worms leave and the fish are free from these parasites during the winter. Infestations with even great numbers of worms do not appear to be fatal or to injure fish to any noticeable extent.

Wormy fish are encountered in wild lakes and streams over a wide area including Canada and the condition is not in any way connected with pollution. As shown above the life cycle depends on the snails and fish-eating birds and the heaviest infestations are found in shallow waters where birds, fish and snails are

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most closely associated. It is certainly not a new disease for it was first described by Leidy in 1856 and no doubt was present when the white settlers first set foot on American soil.

ABSTRACT

PROPAGATION OF MINNOWS AND OTHER BAIT SPECIES. J. R. Dobie, O. L. Meehean, and G. N. Washburn. U. S. Department of Interior, Fish and Wildlife Service, Circular 12, 113 pp., illus. 1948. Copies may be obtained from: Michigan Cons. Com., Lansing, Mich.; Minnesota Dept. of Cons., St. Paul, Minn.; Wisconsin Cons. Com., Madison, Wis. For sale by Superintendent of Documents, Government Printing Office, Washington 25, D. C. Price, 35 cents.

The current shortage of minnows and other bait species, in contrast with the growing demand, has led many bait dealers to consider rearing their supply in ponds or other private waters. The advantages of such an enterprise are many--the cost of raising fish may be less than the cost of seining in distant waters, the dealer can have a supply on hand at all times to meet demands, the angler will have bait in better condition, and the natural food for game fish in public waters will be preserved. For understanding of the basic requirements of this culture, the following topics are covered:

(1) Propagation of bait species: the minnow pond, selection of species, operation of the minnow pond, special considerations in the propagation of suckers, disease and parasite control, control of predation.

(2) Handling of minnows and operation of holding tanks: causes of loss, reduction of loss, source of materials and equipment.

(3) Earthworms, crayfish, and crickets.

(4) Leeches and insect larvae: leeches, May fly nymph or wigglers, hellgrammites, caddis fly larvae, European corn borer, catalpa worm, white grubs, goldenrod gall worms, wood borers.

(5) Life histories of important bait fishes: northern creek chub, northern pearl dace, horny-headed chub, river chub, western black-nosed dace, fine-scaled dace, northern red-bellied dace, southern red-bellied dace, western golden shiner, lake emerald shiner, northern common shiner, spotfin shiner, brassy minnow, fathead minnow, blunt-nosed minnow, central stone-roller, common sucker, northern black bullhead, stone catfish, western mud minnow.

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INDEX

Volume 10, Numbers 1 to 4, inclusive. References to previously published material are indicated: a, abstract; b, excerpt; c, reprint; d, review.

ABSTRACTS ... [a]49-50, [a]105-108, [a]159-160, 219
acetic acid 28
Alabama ..... [a]50
Alday, B. M. 133
algae ..... [a]50
Alvarez, J. ..... [a]108
anadrom ..... [d]48-49
Analysis of Feeding Habits of Rainbow Trout and Lake Trout in Birch Lake, Cass County, Michigan ..... [a]107
Anderson, W. L. 111-116
Aniline Dye in Aquatic Weed Control ..... [c]39-42
aquarium 62-66
aquatics ..... [c]39-42, 53-58, 153-154

bacterial gill disease 19-22
bait species ..... [a]219
Bangos Culture in the Philippines 187-197
bass--
breeding season ..... [a]160
Conchas Reservoir 177-186
fry 138
management 155-156
trap 98-99
Beckman, W. C. ..... [a]159-160
Bennett, L. H. 95-97
Bilharzia ..... [a]108
block system 73-75
Blosz, John 84-87
Bonham, K. 15-18
Brazil ..... [a]107
Brockway, D. R. 117-124
Brook and Rainbow Trout Treated with Sulfamerazine and Calomel or Sulfamerazine and Carbarsone 139-140
Bryan, Paul ..... [a]50
Buller, G. W. ..... [c]218-219
Burrows, R. E. 23-27

calomel 139-140
Cannady, B. B. 73-75
carbarsone 139-140
Carbine, W. F. 187-197
Carlander, K. D. 134-137
catfish 150-152
Cattail Control with Scythe and 2,4-D 153-154
Cement: Its Preparation and Use in Fish-Management Projects 163-175
census--
enumerating populations .. 23-27
precautions 134-137
shocker, electric [c]43-47, [a]106-107
Chamberlain, T. K. 177-186
Channel Catfish Tagging in West Virginia 150-152
Chemical Control Agents and Their Effects on Fish . 125-131
CLEARING HOUSE 50, 108, 160, 219-220
Cod-liver Oil in Diet of Trout 81-83
Collecting Bass Fry 138
Colorado--
spawntaking 76-77
tank, distribution 29-30
Colorado's Glass Fish Tank 29-30
columnaris 141-142
COMMENTS 37-38, 155-156, 213-214
Completion of Fish and Game Survey of Guatemala 18
Conchas Reservoir 177-186
construction--
cement work 163-175
rearing pond 209-212
Culler, C. F. 33
Cultivo de Peces en Estanques Artificiales ... [a]108
Cyclostomes ..... [d]48-49
Cytophaga columnaris as Cause of Fish Epidemics [a]105

Davis, H. S. ..... [a]50, [a]105
DDT--
airplane application ..... 37, [a]107

DDT (continued)
general applications 125-127
Dendy, J. S. ..... [a]50
Denmead, Talbott 155-156
Depth Distribution of Fish in Lower Wheeler Reservoir, Alabama ..... [a]50
Designing Farm Ponds ..... [c]212
disease--
bacterial gill 19-22
columnaris 141-142
control agents 204-205
Cytophaga columnaris ..... [a]105
disinfection 143-149
furunculosis 139-140
octomitiasis 139-140
distribution--
depth, Alabama ..... [a]50
depth, Tennessee ..... [a]50
pondfish 22
trout 206-208
Dobie, J. R. ..... [a]219
Dunn, W. A. 67-72
DuPlessis, S. S. ..... [a]160

Edmister, J. O. ..... [a]105-106
Effect of Airplane Distributed DDT Thermal Aerosols on Fish and Fish Food Organisms ... [a]107
Effect of Population Pressure upon Rate of Growth of Fingerling Cutthroat Trout 15-18
egg picker 30-31
eggs--
disinfection 143-149
fertility test 28
spawntaking 67-72
Eicher, George ..... [c]39-42
Electric 'Shocker' and Its Use in Michigan Streams ..... [c]43-47
Elvehjem, C. A. ..... [a]108
EMCOL 19-22
equipment--
deaerator 88-90
egg-picker 30-31
fish-food beater 36
fish-tub carrier 100
incubator, drip 138
laboratory, mobile 34-35
log-book, hatchery 32
paint mixer 116
raceway, floating 33
sampler 25-27
shocker, electric .. [c]43-47, [a]106-107
trap, bass 98-99
Establishment of 'Stream-Feeders' as Means of Conserving Fish 78-80
EXCERPTS ..... [b]14, [b]157-159
Experiment on the Control of Columnaris with Sulfa Drugs 141-142

Fact and Fiction in Spawntaking 67-72
Facteurs physiologiques determinant les migrations reproductrices des Cyclostomes et poissons potamotoques ..... [d]48-49
farm ponds--
design ..... [c]212
midwestern 111-116
southern 149
Feast, C. N. 29-30
feeding--
cod-liver oil 81-83
diets, trout ..... [a]108
vitamins 117-124
Fertility of Brown Trout Ova at Jonkershoek Inland Fish Hatchery .. [a]106
Fertilization of Our Waters ..... [b]157-159
Fertilization of Recreational Lake to Control Submerged Plants 53-58
Fish-Food Beater 36
Fish Production Program, 1947, in the Southeast 84-87
Fish-Tub Carrier 100
fishponds 198
Fontaine, Maurice ..... [d]48-49
French, T. A. 76-77
Friddle, S. B. 143-149
From Egg to Trout Brook ..... [b]14
Funk, J. L. ..... [a]106-107
Further Studies of Depth Distribution of Fish, Norris, Reservoir, Tennessee ..... [a]50

game fish 177-186
Glacial Acetic Acid and Green Egg Mortality .. 28
Globe-Trotting 58
Graphical Method for Presenting Data on the Growth of Trout 59-61
Gray, J. W. ..... [a]105-106
growth--
graphic data 59-61
population pressure 15-18
rate and sex ratio ..... [a]159-160
Guatemala 18
Gutsell, J. S. 81-83, 139-140

Haddock on Porcupine Bank, September, 1944 .... [a]49
Hagie, C. E. 29-30
Harrison, A. C. ..... [a]107-108
Haskell, D. C. 59-61
Hatchery Log-Book 32
hatchery--
development, S. Africa ... 38

hatchery (Continued)
enumerating populations .. 23-27
trout 3-14
value ..... [b]14
water supply 88-90
Hayford, R. A. 98-99
herbicides 128-131, 153-154
Herman, E. F. ..... [a]108
Hess, A. O. ..... [a]107
Hewitt, G. S. 23-27
Hey, D. ..... 38, [a]106, [a]108, 213-214
Hickling, C. F. ..... [a]49
Hile, R. ..... [d]48-49
House Trailer as Mobile Fishery Laboratory 34-35
Howell, H. H. ..... [a]50

Improved Method for Enumerating Hatchery Fish Populations 23-27
Improved Rearing Pond 209-212
Increasing Production of Bluegill Sunfish for Farm Pond Stocking 199-203
incubators 138
insecticides 125-128
introductions 213-214

Jackson, C. R. 36

Katz, Max 204-205
Keener, G. G. ..... [a]107
kingfish (Atherinidae) ..... [a]107
Kleerekoper, Herman ..... [a]107

laboratory 34-35
lake--
fertilization 53-58
liberalized regulations .. [c]215-218
lamprey ..... [d]48-49
Largemouth Bass Trap 98-99
Lefevre, Marcel ..... [a]50
Leney, D. F. 156
Leonard, F. A. ..... [a]107
Leonard, J. W. ..... [a]107
Lewis, W. M. 134-137
Lindroth, Arne ..... [a]160
log-book 32
Love Life of Fur Seal 133
Lower Wheeler Reservoir ..... [a]50

McLaren, B. A. ..... [a]108
McMullen, R. J. 30-31

Mallards and Bream 61
Management of Game Fish of Conchas Reservoir 177-186
Manning, J. E. 36
Masters, C. O. 78-80
Meehean, O. L. ..... [a]219
Mexico ..... [a]108
Michigan--
feeding habits, trout .... [a]107
growth rate, sex ratio ... [a]159-160
shocker, electric ..... [c]43-47
migrations ..... [d]48-49
Minnesota 95-97
minnows ..... [a]219
mixer, food 36
mortality, green egg 28
Morton, K. E. 28
Mottley, C. M. 177-186

New Compounds for Control of Bacterial Gill Disease 19-22
New Mexico 177-186
New Substances of Possible Value in Fish Disease Control 204-205
New System of Trout Distribution in West Virginia 206-208
Notes on 1945-1946 Bass Breeding Season at Jonkershoek Inland Fish Hatchery ..... [a]160
nitrogen 88-90
Norris Reservoir ..... [a]50
Nota Preliminar Sobre a Preservacao de Ovulos e Esperma do Peixe-Rei da Agua Doce, Odonthestes bonariensis val. ..... [a]107
Nutrition of Trout: Studies with Practical Diets ..... [a]108
nutrition--
cod-liver oil 81-83
vitamins 117-124

Oklahoma 22
Other 176
Our National Aquarium 62-66

Paint Mixer 116
parasites--
Bilharzia ..... [a]108
Clinostomum ..... [c]218-219
protozoan ..... [a]50
Pearson, J. C. 62-66
Pells, F. 32
Philippines 187-197
Phillips, A. M., Jr. 117-124
pickerel ..... [a]105-106
Pike Culture at New London, Minnesota, Station 95-97
PMA 19-22
Pond Owners Get Fish in Oklahoma 22
ponds--
farm 111-116, 149
fish 198

ponds (Continued)
rearing 209-212
populations--
effect of pressure 15-18
enumerating 23-27
precautions in estimating 134-137
Portland Cement
Association 163-175
Power Egg Picker 30-31
Predmore, H. E., Jr. ..... [c]215-218
Preliminary Tests
with Drip Incubators 138
Problems Confronting
the Modern Fish Culturist [c]101-105
production--
increasing 199-203
program, 1947, in S.E. ... 84-87
Propagation of Minnows
and Other Bait Species ... [a]219

Quebec ..... [b]157-159

raceway, floating 33
Rate of Growth and
Sex Ratio for Seven Michigan Fishes ..... [a]159-160
regulations, liberalized .... [c]215-218
Reeve, J. H. 37
Refrigerated Live
Trout Distribution Tank .. 91-94
Removal of Excess
Nitrogen in Hatchery Water
Supply 88-90
Report on Causes of
Deterioration of Trout Fishing, Division of Maclear, Cape Province (1945-46), with Notes on Conditions at Mt. Fletcher and Matatiele, E. Griqualand [a]107-108
REPRINTS ..... [c]39-47, [c]101-105, [c]212, [c]215-219
reservoir--
Conchas, New Mexico 177-186
Lower Wheeler, Alabama ... [a]50
Norris, Tennessee ..... [a]50
Results of Analysis
of Farm Ponds in Midwest . 111-116
REVIEW ..... [d]48-49
roccal 19-22
Rucker, R. R. 19-22, 88-90

salmon 19-22
sampler 23-27
Schuck, H. A. 3-14
Scott, S. A. 100
Seaman, E. A. 34-35, 150-152, 206-208
sex ratio ..... [a]159-160
Shetter, D. S. ..... [c]43-47
shocker, electric .... [c]43-47, [a]106-107
silversides (Atherinidae) ... [a]107
Slater, D. W. 141-142
Snieszko, S. F. 139-140, 143-149
Some Precautions in
Estimating Fish Populations 134-137
South Africa--
Bilharzia control ..... [a]108
hatchery development 38
introductions 213-214
trout fishing ..... [a]107-108
Southeast, production 84-87
Southern Ponds Inspected 149
Spawn from Lake
San Cristobal 76-77
spawntaking 67-72
Stoddard, J. V. 91-94
stream-feeders 78-80
Studies of Protozoan
Parasites of Fresh-Water Fishes ..... [a]50
sulfa drugs 139-140, 141-142, 143-149
sunfish--
mallard raid 61
management 155-156
production 199-203
Surber, E. W. 53-58, 125-131, 199-203
survey, fish and game 18
Survival of Hatchery
Trout in Streams and Possible Methods of Improving Quality of Hatchery Trout 3-14

tagging 150-152
tank, distribution 29-30, 91-94, 156
Tennessee ..... [a]50
Thayer, Marshall 209-212
Time of Activity of
Freshwater Fish Spermatozoa in Relation to Temperature ..... [a]160
Toxicity Thresholds
for Three Chlorides and Three Acids to Fry of Whitefish and Yellow Pickerel ..... [a]105-106
trailer 34-35
trap, bass 98-99
trematodes--
Bilharzia ..... [a]108
Clinostomum ..... [c]218-219
Trout in a Floating
Raceway 33
trout--
distribution .. 91-94, 206-208
growth data 59-61
management 177-186
nutrition ..... 81-83, [a]108
survival 3-14
trout, brook--
calomel, carbarsone, and sulfamerazine 139-140
spawntaking 76-77

trout, brown--
fertility ..... [c]106
raceway, floating 33
trout, cutthroat--
population pressure 15-18
spawntaking 67-72
trout, rainbow--
calomel, carbarsone, and sulfamerazine 139-140
disinfection 143-149
feeding habits ..... [a]107
trout, lake ..... [a]107
Tuttle, E. M. 88-90
Two Years of Fishing in Lakes with Liberalized Regulations ..... [c]215-218
2,4-D 128, 153-154

Use of Block System in Fish-Cultural Operations 73-75
Use of Fish in Control of Bilharzia ..... [a]108
L'Utilisation des algues d'eau douce par les Cladoceres 50

Value of Hatchery ..... [b]14
Vitaminology 117-124

Walker, C. H. 153-154
Washburn, G. N. ..... [a]219
Washington Monument Lot: Fishponds 198
water, deaeration 88-90
water-fleas ..... [a]50
West Virginia--
tagging catfish 150-152
trout distribution 206-208
whitefish ..... [a]105-106
Wider Application of Electrical Method of Collecting Fish ..... [a]106-107
Williams, R. W. 15-18
Williamson, R. F. ..... [b]14
Wood, E. M. 67-72
Wormy or Grubby Fish ..... [c]218-219

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